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CONTENTS

REVIEWS—

Rural development in Queensland, by J. K. Murray	3
Human factors in the changing rural scene, by E. A. Wilkenning	11
Lupin cultivation and breeding, by J. S. Gladstones	19

SYMPOSIA—

The legume-Rhizobium symbiosis, by J. F. Loneragan	26
Problems in legume establishment with special reference to nodulation and nutrition, by D. F. Paton	32
The relative importance of legume species in improved pastures, by G. J. Martin	38
Disorders of animals caused by legumes, by S. Bennett	42

ARTICLES—

Another look at agricultural engineering, by J. G. Porterfield	48
The Agricultural Research Institute, Wagga Wagga, by A. T. Pugsley	51
Could dung eating insects improve our pastures? by G. F. Bornemissza	54

TECHNICAL NOTES—

The occurrence of barley yellow dwarf virus in New South Wales, by F. C. Butler, N. E. Grylls and D. J. Goodchild	57
Two seed borne fungi of french bean— <i>Phaseolus vulgaris</i> L., by J. Walker	60
A comparison of rock phosphate and superphosphate as sources of phosphorus on a black earth, by K. Spencer	63
Digestibility of <i>Medicago tribuloides</i> (Barrel Medic) pods, by J. E. Vercoe and G. R. Pearce	67
Susceptibility of <i>Lucilia cuprina</i> Wied to some organic phosphorus compounds, by R. J. Hart	70

THESES	73
--------------	----

TALKS—

Soil erosion—the causes rather than the effect, by W. J. Roche	77
Fertility decline and its effect on wheat quality and yield, by J. W. Littler	77
Pastures and related nutritional problems, by J. K. Leslie	78
Changing attitudes towards methods of pest control, by A. W. S. May	78
The changing pattern of plant diseases, by T. McKnight	79
The importance of pasture legumes to Tasmania, by N. A. M. Kjar	79

NEWS ITEMS	83
------------------	----

INSTITUTE AFFAIRS—

Fellows	87
Personal Notes	88
Branch Notes	89

OBITUARIES—

Mr. R. E. P. Dwyer	91
Miss Irene Stewart	91
Mr. J. F. Barrett	92

BOOK REVIEWS	37, 50, 71
--------------------	------------

ERRATUM	47
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RURAL DEVELOPMENT IN QUEENSLAND

J. K. MURRAY

In this short review of factors which have influenced rural development in Queensland, and the contributions which may affect it in the future, I have freely drawn upon information which has been made available to me by members of the University staff, Crown Departments and Commissions and the C.S.I.R.O., to whom I wish to express my appreciation.

I have, of course, avoided as far as has been possible, covering the ground so ably traversed by Professor Herbert at the Queensland Royal Society's Centennial Meeting or Dr. P. J. Skerman's "One hundred years of animal production in Queensland".

My object has been to indicate the diversity of the rural development scene, and to suggest that it is desirable for agriculturists to plan their great contributions in an ever-present awareness of the men and movements about them which may participate in the overall result.

At this early stage in the address, I have thought it wise to put the proposition that all Australians in 1959 should feel the necessity that their informed contribution as citizens, as well as to the economy, shall be such as to help ensure that the rural development of Queensland remains with Australians, of whatever genetical make up. The Professor of History, Professor G. Greenwood, has had this to say of our overall situation—

"... the future of this country may well depend upon first, the kind of developments which occur in Asia itself, and secondly, upon the knowledge and wisdom which we as Australians can command in making crucial judgments about the policies which ought to be pursued in relation to Asia."

I do not intend now to pursue this theme except to put before you the words of another historian, Spengler:

"World history is the world court and it has ever decided in favour of the stronger, fuller and more self-assured life."

Aboriginals

A minor but thorny problem which arises, and which might well be talked of here, is that of giving effect to the assimilation of our original Australians, and of part-Europeans. Our history in this matter has not been in advance of general thought in relation to indigenous, primitive peoples and is a source of adverse comment among Asian people and of occasional comment from South African sources. Elements of South African apartheid thinking are not absent from some Queensland towns.

Present Australian policy enunciated by the Commonwealth Territories Department is greatly in advance of previous attitudes. In Queensland we can assist the Native Affairs Department in assimilating the aboriginal and

Colonel J. K. Murray was Principal of Gatton Agricultural College, the first Professor of Agriculture at the University of Queensland, and, from 1945-52, Administrator of the Territory of Papua and New Guinea.

This review is a record of an address given on the occasion of the Centenary Dinner of the Queensland Branch of the Australian Institute of Agricultural Science, September 25, 1959.

part-European into the socio-economic structure. The requirement of exhaustive integration hardly arises as yet.

Native people are now being increasingly employed as farm and stock hands and tractor drivers, and are producers of butter, pigs, grains, cotton, peanuts and beef cattle (500 annually); there are opportunities for us to assist in this development and we would be well advised to give a helping hand.

Bureau of Sugar Experiment Stations

Our President tonight is a member of the Bureau of Sugar Experiment Stations staff. Few industries have owed so much to an institution as sugar does to the Bureau of Sugar Experiment Stations.

The virtual elimination of gumming, downy mildew and Fiji disease, of the greyback cockchafer and wireworm pests has been a very great contribution to which has been added the control of ratoon stunting disease by our honoured friends of this evening, Messrs. Hughes and Steindl. The internationally acclaimed recognition of the control of the "symptomless" ratoon stunting disease by Messrs. Hughes and Steindl must be a source of gratification, not only to the Bureau of Sugar Experiment Stations but to Queensland, and one of pride to the recipients of these tributes and of the Institute's gold medal for their outstanding Australian research contribution of the year.

A memory to me which I cherish is that of the scores of 5 x 5 latin squares of the Kerr and Bell days which contributed so notably to our knowledge of local fertiliser requirements and which has been progressively added to since.

The Bureau's cane breeding programme, together with that of the C.S.R., has been so successful that 80 per cent. of the crop is based on locally bred canes. Further cane breeding contributions are of course continuing, including those associated with mechanical harvesting problems.

We have all read recently of the use, by the Bureau's Mill Technology Division, of radioactive bromine 82 in the investigation of sub-sider problems.

Department of Agriculture and Stock

The work of the Department of Agriculture and Stock, which initiated the work of the Bureau of Sugar Experiment Stations, has extended over the whole of Queensland and its hundreds of research and extension officers have contributed continuously and efficiently to the development of the agricultural industries. The Honourable A. J. Thynne's commencement of the Department with Mr. Peter McLean, and of the Agricultural College, was to be capped eventually by the formation of the University's Faculty of Agriculture during his Chancellorship of the University.

It would be impossible to assess the Department's technological contributions, in all their diversity, made to rural production and its promise for the future, except to say that the present prosperity of the State would never have been reached without the Department's contributions in all the applied sciences related to agriculture and stock. Some slight measure of its achievement may lie in its introduction of some seventy odd crop plants, and its programme of soil investigations, plant breeding, disease and pest control, and the orderly marketing of many products.

Education

A different basic phase of developmental achievements lies in the part played by education. It has needed to be broad as well as specific so that, besides achieving universal literacy, it has enabled operatives to understand the overall development situation as well as to be receptive of new techniques in crop, pasture and animal husbandry.

With automation and general technological advances and less and less demand or need for unskilled labour, the raising of the school age and of the general level of education will help solve social, including unemployment, problems and fit the community for the ever more skilled tasks which are the ever-growing feature of our economy; and it is perfectly clear that we can afford it. The expansion of educational services is a *sine qua non* of modern and, for us, perhaps even continued existence as a people and nation.

The school of the air, the wide scope of correspondence courses, school transport services, junior farmer organisation and the general availability of secondary education are facets which we all welcome. The capping of the edifice by the statesmanlike policy of Commonwealth university scholarships and allowances, with post-graduate possibilities in Australia and abroad, strengthen our professional resources. Such opportunities in tertiary education are accepted now as an essential feature in a State keeping abreast, in Sir David Rivett's phrase, of the "scintillating stream of scientific sensations" as well as a rising cultural level.

In the agricultural sector the picture has been improving, by the much wider opportunities for secondary schooling in agricultural subjects from Atherton to Warwick, the great growth of Gatton College and the passing of the hundred mark in the degree courses at the University in both Agriculture and Veterinary Science.

Notable developments elsewhere, which will affect us, are new degree courses:— at the University of New South Wales in Wool Technology; at New England University in Rural Science and in Agricultural Economics; at Melbourne in Agricultural Engineering; together with a second agricultural degree course (3 years) at the University of Sydney.

One of the developments which might appeal generally and perhaps to people and companies with large commitments in this State would be the foundation of a Chair in Rural Development associated basically with both the Faculty of Agriculture and that of Veterinary Science. Such a chair, with its overall vision, could ensure that we see the rural development picture clearly and see it whole.

The second N.S.W. Agricultural College at Wagga and an arrangement for Victoria's third college at Glenormiston draws attention, in a rather striking way, to the absence of an agricultural college in North Queensland. Tropical agriculture is poorly served in Australian agricultural education.

Educational contributions made by the journalistic and radio services (and later TV) add to the availability of scientific and general

information regarding crops and stock. The material is interesting, and not infrequently absorbing, the best available personnel being drawn from Government Departments and institutional sources.

Libraries and Art

A basic requirement of rural life is being met by the provision of regional libraries such as those located at Mt. Isa, Emerald, Barcaldine and Charleville, with subsidies granted to local Government bodies for buildings, books and equipment. There are now as a consequence over fifty free libraries in rural areas. The less common cultural and technical books are obtainable from the central library in Brisbane.

Something rural areas would welcome would be an Art Train, something along the lines of the Better Farming Trains; this would enable the art treasures of the State to be shared with the rural communities.

General Development

Mining

The direct and indirect contribution of mining, including coal production, to rural development has been and is great. Discoveries at Ipswich, Kilkivan, Warwick and Stanthorpe, and subsequently Gympie, Mount Morgan and Mt. Isa, among others, have repeated general Australian experience that mining activities help to open up country by the provision of communications of all sorts, and the gaining of wealth which assists in general development. Large numbers of miners, as fields decreased in production, as at Gympie, turned to agriculture and played a notable part in, for instance, the Mary River area.

The reconditioning of the Mt. Isa railways is not only important for the silver-lead-zinc-copper and uranium fields, but will be an invaluable boon to the whole rural community and, particularly, to the cattle industry, in the speeding up and increased capacity of passenger and cattle trains; and Mt. Isa town provides a growing provincial centre.

The effect on the York Peninsula of the Weipa bauxite field, estimated to have the almost incredible one fifth or more of the world's aluminium ore reserves, will be very

great; the Weipa-Coen-Laura road will alter the economics of local production.

Electric Power

Travelling through the countryside reveals the mushroom growth of rural electrification. There are now 1,100 localities in Queensland, spread from Cooktown and Normantown to Quilpie, with electric light and power. This growth in service is indicated by a five-fold rise in generating capacity, transmission and distribution lines in the last decade! The difference made to the amenities and to working conveniences of a dairy or other farm by the availability of thermostatic and other automatic controls for hot water supplies, irrigation, incubation, refrigeration, is patent enough, but constitutes almost a revolution in socio-economic affairs.

Atomic Energy

The whole power situation in rural areas may, of course, be revolutionised by developments in the fission, and, subsequently, fusion fields in atomic research and their application.

An intensely interesting aspect, as mentioned earlier, is the use of radioactive isotopes, such as the use of radioactive chromium in labelling red blood cells and the use of Carbon 14 in tracking the movement of compounds in metabolism.

An interesting possibility is that further progress in the synthesis of proteins, carbohydrates and fats, coupled with the availability of unlimited cheap energy, may some day make our present concepts of food and fibre production become a thing of the past!

Plant and Animal

Two individual thought provoking features of plant and animal contributions to increased rural productivity are, first, the ability of Zebu (Brahman) breeds and crosses (Zeboids) to handle the Queensland climate, pests, diseases and periodical food shortages (both in quantity and quality); and secondly, the capacity of *Desmodium uncinatum* to handle the copper and calcium deficiencies of the Wallum soils. The solving of the nodulation difficulties with tropical legumes has reached a most useful stage.

Cattle

One of the most interesting experiences in my early years at Gatton College was a visit to the

Daintree River in the late twenties. There I saw the Zebu cross cattle of Fischer—tick-resistant and smooth, glossy coated. Later R. B. Kelley came to Queensland and informed us of the Zebu crosses and his experience of the Santa Gertrudis cattle in Texas.

Much later I was to see the smooth, short, glossy coated Sindhi and Tharparker cattle in Ceylon, apparently free of ticks; the starey rough coated, unthrifty looking A.I.S. cattle in Ceylon were unimpressive.

So long after the visit to the Daintree, it is good to see that, at long last, Zebus or Zeboids are increasingly being used in Queensland to cope with climatic, pasture and drought conditions, and that the individually developed local Australian tropical breeds are coming into their own. As has been pointed out, it is to be hoped that selection on single gene characters such as horns, colour and simple conformational points shall not dominate complex gened economic characters:— a procedure which has handicapped the dairy and beef breeds for so long. I remember, in the twenties, a Hawkesbury College Jersey of record production being unplaced in a Sydney Royal, because of her horns and lack of "beauty".

The future for the placing of suitably bred animals in the various Queensland environmental regions has never looked brighter nor the economics of the industry, from this angle, more promising.

As pointed out by the C.S.I.R.O. Division of Tropical Pastures, the potentialities of the cattle industries are great and the development problems far from depressing. The present 30 million acres of improved pastures in the States to the south of us, when compared with our 2 million acres, seem and are a great achievement. But it seems certain that the breeds, pastures and fertiliser improvements which are possible in our 40 million acres of spear grass country, with a rainfall of 30"-45", will treble the number of cattle now carried there. The Rodd's Bay experiments with *Stylosanthes* and fertiliser may be only the plant part of a great expansion; the basic scientific work with cattle at Belmont is of great importance.

The possibilities with the 2 million acres of Wallum country and the 20 million acres of

Brigalow are such that, added to the spear grass 40 million acres, we can plan and, with the will, make effective early, the trebling of the production in these areas.

Sheep

The work done in relation to sheep and wool has much improved the production and economics of the industry. The increase of Australia's sheep from 100 to 150 million is an extraordinary vindication of the success of the myxomatosis campaign; and the favourable comments on the Myxoma KM13 strain of lessened virulence strikes an optimistic note, though the emphasis on destroying remaining rabbits (of possibly resistant strains) is strongly stressed. The Mules operation and development of polled Merinos, as well as other factors, are notably reducing blowfly strike.

Acclimatization adjustments of sheep and cattle strains to meet local conditions seem to be more certainly based.

The contributions of the SI-RO-processes generally in relation to wool as a clothing material have successfully countered some of the synthetic substitutes propaganda; but low cost of production per pound is of the essence.

Dairying

The major Australian dairying problems lie in the area northwards of Port Macquarie and it is unfortunate that the major facilities for research in dairying lie in the county of Cumberland, N.S.W., or to the south of it. In particular the dairy industry of Queensland is worthy of fostering by C.S.I.R.O. and the grants of dairy organisations. The yield per cow in Queensland is less than three-fifths of that in Victoria, less than half of that of New Zealand, and the yield of butterfat per acre (an economic factor of the greatest importance) is even less satisfactory.

People of European stock like ourselves have had little experience of dairying in the tropics and sub-tropics.

One of the most remarkable and, for long, ignored efforts has been the dairying centre on the Daintree River (16° S.) where Zebu blood was brought by Fischer in the '20's, and relatively great freedom from tick infestation and a climatic tolerance among the cattle obtained.

The soil fertility and pasture composition problems of Australia to the N and NW of Port Macquarie require a much greater allocation of Australian research funds. Commonwealth efforts by C.S.I.R.O. and Departmental grants are unlikely to give more rewarding results elsewhere in Australia, or to be nationally more important.

The load on Australian finances of a subsidy of £16m. a year to the dairying industry more than justifies an annual research grant of £4 million annually with a view to bringing about a reduction of the dependence of the industry on subsidy (which is sociologically and economically undesirable) as pointed out by the Chief of the Tropical Pastures Division of C.S.I.R.O.

C.S.I.R.O. Generally

This research organisation, with probably greater international prestige than any other institution in the southern hemisphere, has recently established a Division of Tropical Pastures in Brisbane, and it is housed in the happily named Cunningham Laboratory. This Division constitutes one of the most important and progressive steps in agricultural science taken in the Commonwealth. It is the most important C.S.I.R.O. development in northern Australia, and the only division (in a total of twenty) which is located north of Sydney. C.S.I.R.O. headquarters and six divisions are in Melbourne, seven divisions are in Sydney, three are in Adelaide, and three are in Canberra. In addition to the C.S.I.R.O. divisions there are eighteen, perhaps nineteen, independent sections "which have not reached a stage of development . . . to justify their designation as divisions"; *none* of these is north of Sydney and eleven of them are in Victoria.

The normal explanation of this fantastic situation is that there are in Queensland field stations and laboratories of southern based divisions, and that much of the work done in the south is applicable to northern Australia. Both of these things are true; first class, important research has been and is being done by the Queensland based activities. But equally true it is that much of the work done in North Western Europe is applicable in southern Australia. The worst shortage of scientific en-

deavour in relation to crops and stock is in the tropics and sub-tropics. The Australian dairying problems, for instance, are rather those of Port Macquarie and north of it, but the Dairy Research Section is located in Melbourne.

As in society, so in States; unless there is a purposeful policy to reduce the extremes of wealth and poverty, the rich get richer and the poor, poorer—whether in money, or scientific endeavour.

The very least that the northern half of Australia can expect now is Commonwealth Government policy to set up Divisions of Tropical Animal Health and Production, of Tropical Food Preservation and Transport, and of Tropical Soils.

To bring about the early setting up of such divisions Queensland, the State with the greatest tropical and sub-tropical potential in crop and animal production, should bring to bear on the Commonwealth Government all the pressure, continuing pressure, which is proper in a Federation of States.

Irrigation

The figures given by W. H. Nimmo regarding continental rainfalls place Australia with a 16 in. average in the poorest position, with averages of 24 in. for Europe, 25 in. for Asia, 28 in. for Africa, 29 in. for the U.S.A., 50 in. for South America. Reliability of rainfall in Australia is generally low.

Of the Australian water supplies Queensland has half, and a considerably greater volume of underground water than any other State. However, evaporation and stream flow losses are greater than those of other States.

So far the big irrigation projects, for instance the Eildon Dam of Victoria, the M.I.A. of N.S.W., and the Snowy Mountains Scheme have been in other States. It is not for lack of suitable sites here. The proposed Burdekin Dam would store one and a half times the storage of the Snowy Mountains Scheme and at a storage cost of less than half per acre foot. Similarly the Nathan Gorge Dam would store somewhat more than the Eildon Dam at one third of the cost.

These projects have not yet been given the financial backing by the Commonwealth that

has been accorded other projects in southern States; but they should be reviewed in relation to all the aspects of each scheme, particularly in view of the advances in soil science, and of the tropical and sub-tropical possibilities in the Australian economy in both the stock and crop domains.

There are many small schemes in our State and some of medium size. The Tinaroo Falls and Tully River dams have each storage for some 300,000 acre feet but the latter mainly for hydro-electric purposes. The Mareeba-Dimbulah project will eventually irrigate 40,000 acres. The Moogerah dam in the Fassifern Valley will store about 75,000 acre feet and will be capable of irrigating 12,000 acres. The present total area under irrigation is 160,000 acres, of which 70,000 are under sugar.

The Geddes water harvesting procedures may make a considerable contribution under a wide variety of conditions.

Rainmaking

The Snowy Mountains, Mt. Lofty area and Darling Downs projects, using silver iodide combinations for nuclei dissemination, will be watched with interest since the normal precipitation from cloud formations is but a small fraction of their water content, and increases of a minimum of 15 per cent. in the annual rainfall of areas are regarded as feasible. The consequences of increased rainfall on the terrain should not be damaging generally, in view of the programmes being designed to offset drought and seasonal shortages in precipitation.

Finance

The services of the Rural Credits Department of the Commonwealth Bank are much in our minds, perhaps, as a consequence of its grants from profits to facilitate research, as in the Downs soil fertility project under Professor Teakle's direction; and Prof. J. R. A. McMillan's original contributions, in Australia at Gatton College, to hybrid maize production. It has provided a million pounds for such purposes. But its great purpose and achievement has been, in the words of Sir Earle Page, to cover "the barren area of credit" between the selling of the "crop" immediately after harvest-

ing and its ultimate complete distribution. Last year £100 million was thus lent for the orderly marketing of our agricultural produce.

Potentialities

Continuously since my first visit to this State in 1914, there has been emphasis on its potentialities, both by Australians generally and by Queenslanders. Both are right. But the word potentialities has something of an opiate in it; emphasis needs to be on development. Many countries, like Japan, have very limited physical resources, but they have made quite extraordinary use of their people's abilities and of western knowledge. In a hundred years they changed a closed feudal system to the great democratically governed country of today.

Given the smallness of our population and the newness of the problems of the wet and dry tropics and sub-tropics to people of European stock, the progress made in the century by Queensland has been a unique and great achievement and one for which too much credit cannot be given to the great-hearted men and women who accomplished it.

The work done by Crown Departments in encouraging and aiding exploration and in bringing land occupation within systematic legal tenures was a basic task, effectively done. W. L. Payne's recent recommendations provide a basis for future administration. The surveying and building of roads, the development of the great system of railways commencing with Ipswich to Big Camp (Grandchester!) and culminating with the fast Diesel passenger and goods services of today, the telegraph, telephone and postal services from Birdsville to Somerset were great achievements by any national standard.

The century of service given by the railways has been a dominant factor in our development; and recent improvements promise much. In view of Section 92 and its effect on interstate haulages, the railways might well be relieved of some of the capital charges on the interstate permanent ways.

More recently the regeneration treatment of 600,000 acres of native hardwoods, cypress and hoop pines and the establishment of 85,000 acres of softwoods are great assets in rural development.

Soil conservation measures are conserving our soil capital, and the measures to conserve the water resources of the artesian basin are a service to the security of pastoral country.

Conservation of fodder is receiving attention, too, and the work of the University and of the Department of Agriculture and Stock in this field is assisting in the lessening of stock risks to an appreciable extent.

Decentralization

The extreme South Australian example of centralization where Adelaide has five-eighths of the State's population has no counterpart here. But the necessity for decentralization in the State's interest, as well as that of the rural people, is manifest. The development of the provincial centres occurring along the Queensland coast at roughly 100 to 200 mile intervals does not present great problems if the will accompanies the stated policy to implement it. With today's communications, many Government Departments need only have a headquarters organisation in the capital city, and the control and direction of activities located in the 10,000 to 40,000 population centres of which we fortunately have many.

Such developments would doubtless have occurred much earlier and in a broader way, if Sir Samuel Griffiths Constitution Amendment bills, which passed the Assembly, had not been rejected in the Legislative Council. The first of these bills provided for three Provinces of North Queensland, Central Queensland, and South Queensland, each with a Deputy Governor and a considerable degree of autonomy, but one central Parliament; the second bill differed from the first mainly in providing for only two provinces, North Queensland and South Queensland.

Conclusion

I would, then, urge the interest of the members of the Institute in decentralization, so that the rural development of this State, *in all its aspects*, may increase in tempo, and that the lives of those associated with it may be more effective and fuller. And in this context of decentralization and rural development, I would again quote Spengler—

"World history is the world court, and it has ever decided in favour of the stronger, the fuller and the more self-assured life."



Your life is more pleasant with Wine

HUMAN FACTORS IN THE CHANGING RURAL SCENE

E. A. WILKENNING

Rural society here in Australia as in all countries is undergoing rapid change, a statement which could have been made truthfully at almost any time in the past fifty years. Likewise, it could have been said that there are many problems growing out of this change which have required the attention of scientists, students and public agencies. Yet, the need for attention to problems occurs only when it is recognized that something is out of joint with what we think it ought to be. While perhaps things are not badly out of joint, rural society in the industrialized nations is going through the growing pains of social and cultural development as well as material and economic development.

The problem of rural society is that of how it can become an effective part of the larger society of which it is a part but of which it has almost always lagged behind in economic and social benefits. Perhaps this is less true here in Australia where you have a lower ratio of people to the land than in almost any other country of the world, but, it may come here as the pace of industrialization increases. How can the people, who depend upon the land, keep up with the pace of those depending upon other pursuits, who can take advantage of mechanization, automation and mass production methods more easily than can the person who depends upon the land?

Income figures for the United States will illustrate what has happened to the person making his living from the land. The per capita farm income from farm sources in the

United States declined from approximately \$850 in 1948 to \$700 in 1958. At the same time per capita income from nonfarm sources climbed from approximately \$1750 to \$2000. If income to farmers from nonfarm sources is included, the per capita income to farmers remained at about the same figure of \$1000. One must keep in mind that the farm population during this time decreased about 6 million and the number of farms by one million, from 5.8 million to 4.8 million. Hence, while the total United States nonfarm income went up 48 per cent. during this period, total farm income from farm sources went down 31 per cent.

Consequently, the problems of rural society in the industrialized nations, while different from those of the non-industrialized, are just as crucial. It is going to require all the efforts of the plant, animal and social scientists, educators, public servants and commercial people to keep those depending upon the land from becoming much worse off than they are now, as compared with the nonrural segment of our society.

Professor E. A. Wilkenning is Professor of Rural Sociology, University of Wisconsin, U.S.A. During 1959 he was Fulbright Research Scholar in Rural Sociology at the University of Melbourne.

This article is based on a public address sponsored jointly by the University of Melbourne Extension Committee and the Institute and delivered on October 30, 1959.

About fifty years ago in the United States, rural people became conscious of their disadvantages as compared with their urban relatives. They were losing what they thought was the cream of their youth to the cities. Opportunities for social contact and levels of living of the country people were low as compared with the city. Later on there were the problems of providing better schools and improving rural institutions. There was also the problem of communicating scientific information to rural people. These problems were tackled on a very empirical level, for the most part, by rural sociologists and others. They relied little upon sociological theory, partly because there was no theory appropriate for these problems at the time, and partly because of their commitment to the solution of immediate problems.

Today rural sociology has outgrown its earlier "welfare" orientation and is concerned with a scientific approach to the study of rural life in its many aspects. Increasingly, there has been an attempt to define the problems of study in conceptual terms so that the findings have more general significance and are cumulative.

Incidentally, the main advantage of the use of theory in studying a problem is that, if properly used, it gives us an understanding of problems which are not confined to a specific time and place. It should enable us to make more efficient use of our meagre research resources. But, this places a greater burden upon the researcher or upon his colleagues to interpret his results so that they make sense to the person concerned with a specific problem at a specific time and in a specific physical, economic and social setting. This is where many of us would like to crawl back into our academic shells and say, "We have provided the theory, now you make whatever use you can of it." To my mind the most challenging task in the area of rural sociology is that of interpreting the findings of research and of planning the network of form and function to fit into the many unique situations. This requires a respect for theory and fact, an awareness of the wide variation in people, and a sense of values which is needed to guide human

behaviour in the direction of greater satisfactions.

Study of the human side of rural society has taken many different forms and will be discussed under five general headings:

1. The population characteristics of rural people, including residence, rural-urban migration, and nationality groups;
2. Community structure and development.
3. Rural organizations and agencies.
4. Communication and technological change in farming; and
5. Farmers' attitudes.

These problem areas have received different emphasis at different times, depending upon the trend of the times in the rural scene.

Rural Population Characteristics

The development of a self-consciousness on the part of rural people produced questions as to *who* the people are, *how many* and *what* is happening to them. Out of this self-consciousness on the part of rural people in the United States arose studies of the rural population: origin of the people, movement to the city, natural increase, youth studies and more recently studies of the aged in rural society. The rapid industrial growth of the early 20th century resulted in heavy rural-urban migration. Many felt that rural society was being fished out leaving nothing but the "bullheads and suckers" as one sociologist put it. Hence, a number of studies were launched to determine the selectivity of the city in attracting rural youth. While there is not agreement as to whether the most intelligent and able are going to the cities or not, much has been learned about the selectivity of rural-urban migration with respect to age, sex and occupation. In brief, girls migrate sooner and in larger numbers than men, leaving a higher proportion of men to women of marriageable age. These findings have been of help in understanding the problems of rural youth, of adjustment of the city migrant, and the problem of rural education.

For example, two factors were found to compound the problem of education in rural areas. The high birth rate and the migration of youth to the cities meant that the burden of education per capita of those in the productive years

was many times as great for the rural areas as for the urban. In the extremes this means that a rural State such as Mississippi pays almost twice the proportion of its income for education as does New York but with a per capita pupil expenditure of about one-third. Such inequities in the burden of rural society for education have resulted in state and national programs of aid for education. Even yet, however, the main burden of primary and secondary education in most States is borne by the local district and not by the state or federal governments.

One of the greatest concerns in recent years in the United States is that of how to encourage the movement out of agriculture in areas of low farm income. Numerous studies are underway at the present time to determine (a) the motivation for migration from farm to nonfarm areas, (b) the occupational and educational aspirations of youth in rural areas, and (c) the problems of providing nonfarm opportunities in areas with more people than the land justifies. One study in Oklahoma, where one fifth of the open-country labor force was unemployed, found that 44 per cent. were unwilling to accept other supplemental employment and that only one-fourth were willing to leave the area for other work. In this case the problem of adjustment to a new environment and attachment to the local culture were more powerful than the economic forces attracting them to other areas.

These and other studies suggest that the problem of raising the level of income and living among people in areas with a high ratio of people to resources is a social as well as an individual matter. The people are not likely to solve their problems themselves, but will become relatively worse and worse off as compared with those from other areas with better resources. While such areas have apparently not developed in Australia they could become so if the idea of closer settlement is carried too far in areas with poor land or with uncertain climatic conditions.

Another aspect of population studies of much concern in recent years is the study of the rural-urban fringe. The centripetal forces pulling rural people into the metro-

politan complex and the centrifugal forces pushing them from the central cities to the more spacious suburban and sub-suburban areas are producing one of the most challenging problems for the social scientists. The fringe is frequently a no man's land with respect to government and public services. Rural institutions are inappropriate for the increased number of urban workers who wish to enjoy more space, cheaper land and a few vegetables, fruits or other outdoor hobbies to occupy the leisure time available due to shorter working hours. This fringe settlement has been made feasible with the use of the septic tank and the automobile. Yet, metropolitan government and services have not extended themselves to these areas which may reach to forty and fifty miles from the central city.

Recent studies by sociologists have shown that the fringe areas tend to attract people with children, with farm backgrounds and people who are low social participators. We need to know to what extent the fringe development is a temporary phenomenon—is a kind of zone of transition of people moving into or out of the city, a kind of temporary "camping ground" or is a part of the permanent ecological structure of contemporary life.

Another topic falling within the general area of population studies in the United States pertains to nationality and ethnic groups. This has been an important area of concern in the past in those parts of the country absorbing large numbers of European migrants in the latter 19th and early 20th centuries. This is an area which is likely to become of increasing concern here in Australia with present emphasis upon immigration. Studies in the United States have shown how reactions to government programs, to education and to the acceptance of new technology is influenced by the social and cultural patterns of nationality groups. Resistance to education has been found to be associated with the emphasis upon family solidarity among Germans in Wisconsin. Resistance to recommended farm practices was also associated with family solidarity and lack of emphasis upon material values among a Polish group. The attitudes and values of many of the Europeans reflect the peasant back-

ground from which they came in which possession of land and family solidarity were the main assurances against deprivation and loss of status. By taking into account these values, educators, extension workers and others have been able to gain their cooperation and participation in programs for their benefit. So much for the population and background characteristics of rural people.

The Rural Community

Among the earliest studies in rural sociology were those concerned with the total rural community. They pioneered in the study of the rural community as a unit in which people occupying an area used common services and were bound together by a certain degree of interdependence. The delineation of communities has been a favorite occupation of rural sociologists for many years. While this interest in the delineation of what were called natural communities was of much use to those concerned with school consolidation and extension programs, this interest has been replaced by a concern for the more fundamental problem of the nature of the community structure, the interrelationships of community services and of how to organize and stimulate communities to attack their own problems. Some of this effort goes under the currently popular term of "community development."

The concept of community has always had a strong appeal in the United States because of the value placed upon local autonomy and local initiative. This emphasis in its extreme form has become a kind of panacea for problems of all kinds, government, education, soil conservation and mental health. Nevertheless, this interest in the total community, its people, services and institutions has led to a number of important contributions. Community surveys, something like the McIntyres' *Country Towns of Victoria* have been very useful in pointing out the nature of the community life in its various manifestations. This book is full of insights into community life in Victoria and could provide the starting point for studies of community structure and functioning here in Australia.

More recently, there has been concern for the process of community policy-making and

action. How do people get things done? For example, it was found that in one community two or three individuals influenced most decisions in educational, political and other secular areas. Furthermore most of the decisions were made through informal contact. The formal meetings served to publicize these decisions, with the real issues seldom being brought out into open discussion.

The studies of the Royal Commission of Saskatchewan, Canada, have pointed out the problems of rural villages and communities in adjusting to a decline in population in the wheat country. Rural communities all over the world are faced with the problem of how to overcome the disadvantage and cost of providing adequate schools, churches, health services, libraries, recreation, markets, etc., to relatively few people who are frequently scattered over a large area. I have been much interested in the way you have tackled these problems here in Australia, including the Flying Doctor service, schools and library service in the sparsely settled areas. Dr. James Conant, an authority in education, has recently recommended that if we are going to provide the kind of secondary education needed in the present atomic age, the schools must have a graduating class of at least 100 students. At present four-fifths of all United States high schools are below this level, most of which serve rural areas.

The development of more appropriate institutions and services to rural people in Australia, as in the rest of the world, is going to require knowledge of population growth and composition, and a knowledge of the social as well as economic costs and gains of larger scale institutional systems. It will require planning and a program of development which takes into account local and regional as well as state and national interests and which considers ways of obtaining local support rather than opposition which so often happens. The efforts in community development at New England University and at the University of Adelaide are promising steps in this direction.

Certain types of community studies have helped to explode some of the myths which we have held about American rural life. One of

these myths in the United States was that there were no social classes in rural areas, with the exception of the South. There were supposed to be no marks of inferior and superior status and everyone was supposed to associate with everyone else. Following the lead of sociologists studying urban life, rural sociologists began to delineate the status and class differences in rural communities. In most areas two or three fairly distinct levels of people could be distinguished which were reflected in leadership, group membership, influence upon decisions, education and levels of living. An understanding of such social differences has been of great interest to church and school leaders and to extension, health and other officials.

To what extent is the Australian idea of "equality" fact or myth and how are social differences manifest in rural communities? This is only one of the many aspects of rural social structure which should be of much aid to institutions and agencies serving rural people.

Rural Organizations

Closely related to interest in the rural community is the interest in rural organizations. It was recognized that if rural people were to do anything about their situation they needed to organize at local, state and national levels. In the United States the dissatisfaction of farmers with prices, railroad rates, and markets stimulated the organization of co-operatives and politically oriented organizations. Recognition of the need for educational and social activities stimulated the growth of such organizations as the Farm Bureau, the Grange and the National Farmers Union. Yet, frequently participation in these and other organizations is small, the organizations are ineffective and rural organizations have a high mortality rate. We have long been concerned with participation and leadership in rural organizations. We have been able to identify the characteristics of the leader, the participator and the non-participator of different types of organizations. In general leadership comes from those of higher socio-economic status and participation from those of middle and higher status. Other factors affecting participation include age, presence of children in

family, physical isolation, and social aspirations of the individual.

Recent studies have focused more upon the functioning of the organizations themselves, how they recruit members, how they keep them informed, how they select officers, conduct discussion, arrive at decisions and carry out their objectives. Farm people tend to lack experience in conducting formal meetings and affairs. They are not part of an organized group such as government agency, private firm or factory. The farmer, more than anyone else is his own boss and proud of it. But, this very fact plus his physical and social isolation makes it more difficult for farmers to benefit from collective action to the same extent that other groups in our society do. If the farmer is going to become aware of the demands of the current market and the many other factors affecting his returns he must have organizations which are active and alert in keeping him informed and in crystallizing his opinions. If he is going to obtain the services and facilities which he has a right to, he must know how to arouse interest, to compromise conflicts and to obtain the co-operation of the various public and private agencies. I have met some of your organizational leaders here and they recognize these problems.

There is much confusion in the United States, and perhaps some here, among the various farmers' organizations as to who represents who, and what kind of policy they should support. In part this is part of the struggle for group survival and influence, but in part it is also a question of what kind of organization, the special commodity type or the general type, serves the farmers' interests best, it is a question of how policy is arrived at, and of the understanding of the members of the issues involved and of the kind of action needed. These problems have been studied to a very small extent in the United States or elsewhere to my knowledge but there is need for their objective study and analysis in order to assist farmers in solving their problems through group action.

Another aspect of rural social organization which I would like to touch upon is the role of the professional worker including, the

minister, the teacher, the welfare worker, doctor and agricultural worker. If changes are made in rural society these people are in the vanguard. Almost all professional workers going to rural areas have the same type of problems: professional isolation, poor living facilities, apathetic or unco-operative attitudes of their clients and conflicts with other professional workers. Without the various built-in devices for assigning teachers and other professional workers to rural areas they would be even fewer. Yet, in the United States the ratio of people to doctors in most rural counties is two times that in the urban counties. The turnover of ministers, teachers and other rural professionals is much higher than in the cities. Yet, effectiveness with rural people requires a continuity of contact and a development of personal relationships on the local level. But frequently personnel and promotion policies of agencies operate to increase rather than to decrease this turnover in rural areas. On the other hand there is usually a high degree of devotion of the rural worker to his job.

A recent study of the role of extension workers in Wisconsin shows that the things they like least about their work are night meetings, reports and paper work, too much pressure from local groups, lack of opportunity for pay and promotion and lack of opportunity to specialize. On the other hand things they like most are the opportunity to work with people, the varied aspects of the job, things they learned, and the freedom in planning their work. Most did not feel strongly about the night meetings and the paper work. So the conflicting pressures from local groups, the lack of opportunity for pay and promotion (4-H club agents) and the lack of opportunity to specialize were the greatest disadvantages. These tend to be offset by the relative freedom to plan their work in accordance with local needs and interests, by the opportunity to learn something on the job for later use and by the opportunity to work with people. We need to learn more about the interests, motivation and relationships of the professional worker if we are going to be able to recruit, train, and keep the calibre of people needed to bring about the changes needed in rural areas.

Communication and Technological Change

Now we come to that aspect of rural sociological research with which I have been most closely identified—communication of farm information and technological change in agriculture. While rural sociology grew up as an offshoot of agricultural economics in many states there has been relatively little joint effort to study the farm as an institution influenced by both social and economic factors. Economists have recognized the importance of the human factor in the farm enterprise but have not known just how to take it into account. Sociologists in an attempt to establish a separate discipline have steered clear of studies of economic activity for the most part.

A recent type of study has dealt with specific farm innovations such as hybrid corn, pasture improvement and livestock management. About twenty years ago the classic study of Ryan and Gross in Iowa of the diffusion of hybrid corn, showed how sources of information and social factors affected the adoption of hybrid corn. Since that time well over a hundred studies have been made in this area of communication of farm information and acceptance of new ideas in farming. In 1955 a publication was prepared for the use of agricultural workers based upon the finding of these studies. About a year ago they were preparing for a third printing of this publication, *How Farm People Accept New Ideas* (Iowa State College of Agriculture and Mechanical Arts).

Studies in the area of the acceptance of new ideas have focused upon several different problems. Following the pattern of the Iowa study of hybrid corn some studies have shown how the rate of acceptance of new ideas is a function of (a) the nature of the practice itself, (b) of external circumstances such as the weather and (c) of the extent of interaction among the farmers in influencing others. For those interested in statistics, the adoption of simple innovations has been found to follow a bell-shaped curve when plotted over time which means that a slow rate of adoption is followed by an increasing rate followed again by a declining rate. The time for this process to complete itself varies with the type of practice and other forces affecting its rate of

acceptance. For hybrid corn it was about 10 years.

Other studies have focussed upon the communication of information about new practices. It has been found that the average farmer obtains different types of information from different sources before adopting a new idea. He is likely to hear about a new practice through farm papers, learn more about it by talking with agricultural specialists, be convinced to adopt the practice by talking with other farmers and gain further information about the details of how to put the practice into operation through the commercial dealer or labels on the container. The particular combination and order of information sources used will depend upon the type of farmer and upon the particular practice. The important point is that farmers obtain different kinds of information and assistance from different types of sources. Each makes its special contribution to the process of accepting a new idea.

Lionberger and others have studied interpersonal communication among farmers. They have found that personal influence among farmers in Missouri is widely dispersed. Most farmers are influenced by those who live close by and are similar to themselves. Their contacts follow those established through visiting, work exchange and other activities. This means that the communication of information and attitudes with respect to new ideas is a process which starts with the innovators and fans out to others in the area. The innovator may or may not have a wide range of contacts himself. The acceptance of the innovation is dependent upon the extent to which information and influence is transmitted from person to person among all groups and levels of farmers. Barriers to this process occur in the form of physical isolation, social isolation, nationality and class differences. Where such barriers occur the new idea must be introduced into each group or level. Hence one needs to know something as to the nature of the leadership and influence patterns in order to select demonstrators, arrange field days, etc. The problem is quite different in an area where one or two farmers are looked to as the leaders or influentials—as in areas characterized by a closely knit ethnic, kinship and

religious ties—compared with an area where leadership is diffuse.

Another recent emphasis in technological change studies pertains to the influence of the family upon decisions affecting the farm. After all the farm is essentially a family owned and operated institution here as in other countries. A study in Wisconsin revealed that women are involved in farm decisions (a) when they contribute to the farm work, (b) when the family is in debt and (c) when the level of living is average or below. This indicates that the woman is concerned with what is spent for the farm, when such expenditures are likely to affect immediately what is spent for the household. If this is true here in Australia, there is reason to consider the interests of the woman in getting changes accepted on the farm. The United States Extension Service has recognized the significance of the family to the extent of initiating a Farm and Home Development approach in extension work.

In any case the effect of standards of living upon farm expenditures have been clearly shown. By this I mean that the expenditures for farm operating expenses will take second priority until the minimum needs of the family, as they see them, are met. This standard of living varies for different parts of the United States. In the South it was about half as much as it was in certain northern areas. But, once a certain level of living has come to be accepted, the family will tend to take available cash and even go into debt to keep up this standard before putting much money into the farm enterprise. This is the conflict between the family and the farm enterprises and is most acute for those families in the lower income levels. This is one reason why families, once they get below the minimum level of income needed to support the accepted standard of living, get in a kind of vicious circle which they have much difficulty in getting out of. This might be true in some of the dairy farming areas in Australia. We need to know how to approach people with sub-standard farms and how to assist them to either move out of agriculture or to improve their situation. The alternative is the continued existence of pockets of rural poverty.

The family has an influence upon other aspects of the farm. The family influences the size, type and continuity of the farm enterprise. Yet, there is little systematic study of how the interests both farm and family enterprises can enhance each other under different kinds of circumstances in the transfer and ownership of property, partnership arrangements, budgeting, and planning. The things that worry farm families more than anything else are how to interest the son to stay on the farm without making it too easy for him and hard on the parents, how to transfer property when many children are involved, how to keep up the home and still not jeopardize the farm, etc. Yet, these are problems for which we have provided little information or assistance.

Farmers' Attitudes

The final area I wish to discuss briefly is the description and analysis of farmers attitudes. The idea of the Gallup Poll has been accepted over the world. Even certain farm papers in the United States take polls regularly among farmers on issues pertaining to them. The sociologist is equipped to go beyond the Gallup type of opinion poll. Studies of farmers' attitudes toward retirement plans have assisted in the formulation of federal legislation on retirement benefits for farmers. Studies in attitudes toward health and medical services have assisted health workers in meeting the health needs of rural areas. Of particular significance have been studies of consumer attitudes toward agricultural products which have led in some instances to improved grading and a redirection of plant and animal breeding. It would seem that assessment of consumer interests and buying habits in Australia might be of aid to the meat, poultry, fruit and vegetable industries not to mention the all important

wool industry. Farmer opinion studies could be of great help to the government in establishing policies and programs.

Also, if the farmer and grazier of this and other countries are going to be able to compete with the highly organized manufacturing industries they must make scientific studies not only of the products they produce but also of the people who use them. Industrial firms are spending huge sums on this type of effort in the form of motivational research. They are trying to find out what the consumer wants, or thinks he wants, and why, and then tailor the advertising, if not the product, to fit those wants. I am not suggesting that this is always desirable, but the farmer must combine with the processor of his products to understand his market, its trends and potentialities and how his product can be modified to take advantage of current trends. Agricultural products will sell themselves when the alternatives are few, but not to people who can pick and choose.

Summing Up

This presentation has been based upon what I feel we need to know about the human factor in rural society as well as upon what has been done. These have not always been clearly distinguished. But I have tried not to bore you with who did what when, but rather to illustrate the kind of things those concerned with rural people have done, are doing, and ought to be doing. Whether these things have been done or will be done by rural sociologists is not of primary importance. The important thing is that something be done about them in order to assist in keeping rural people from becoming a disadvantaged class. In short, I appeal to you to give some attention to the human aspect of the problem with which you are concerned.

LUPIN CULTIVATION AND BREEDING

J. S. GLADSTONES

For some years lupins have been grown in parts of Western Australia for sheep feed and green manure. They thrive particularly well on sandy and gravelly soils in better watered areas of the South-West. Recently, improved alkaloid-free varieties introduced from Europe have been found to grow equally as well as the existing bitter varieties (Gladstones 1958*b*, 1959).

The history of the development of lupins from bitter, weed-like plants to their present form is very interesting. Primitive bitter varieties have been grown in Mediterranean regions for 2,500 years or more, but it is only within the last 30 years that systematic breeding work has been undertaken within the genus. In this short time, advances made by German breeders have placed certain types of lupin among the true crop plants, with considerable potential as grain legumes for light soils in suitable climates.

The main species grown in Mediterranean countries, from classical times onwards, has been *Lupinus albus* L. Its cultivation was described some 2,000 years ago by Theophrastus (Book 8.XI.8), Varro (Book 1.XXIII.3), Columella (Book 2.X.2 and Book 2.XV.5), and Pliny (Book XVIII.133-136 and Book XVII.260). According to Zhukovsky (1929) seeds of *L. albus* and *L. digitatus* Forsk. have been found in Egyptian tombs of the 12th dynasty, believed to date from about 2,000 B.C. The classical writers describe *L. albus* as being grown both for green manure and for grain.

There are few records of lupin growing following the decay of Roman civilization. Piero de Crescenzi (1724)—quoted by Pieters (1927)—writes that in Tuscany the expert farmers sow lupins in July and August, and in October. "They cut them down with spades

and lay them in furrows. There they sow the grain and cover the seed with the plough. The fields cultivated in this manner produce a plentiful crop next summer." French botanists of the late 18th century, e.g. Villars (1789) and de Lamarck (1789) describe *L. albus* as being cultivated on poor, arid soils in Southern France, and the synonym *L. sativus* bears witness that this was the main cultivated species of the time. Today it is grown in Italy, Southern France, Spain, Portugal, Egypt, the Sudan, and Abyssinia, sometimes for green manure but mainly for grain. The seeds are steeped in hot water or brine to remove the bitter alkaloids, and used for human consumption or as protein-rich stock feed.

Lupins were introduced into Northern Germany early in the 19th century and their cultivation spread rapidly on the sandy heath soils of Lower Saxony, Brandenburg, Mecklenburg, and Pommern. The main species was *L. luteus*, which was found to grow well on sandy acid soils which had hitherto been considered too poor for agriculture. It was used widely for green manuring in rotation with rye and potatoes, and later as winter feed for sheep. However after about 1870 there was a number of outbreaks of lupinosis, an often fatal disease of sheep occasioned by grazing on lupins. This was at first thought to be due to alkaloids, but the sporadic nature of its occurrence seemed to indicate that other factors were involved. (Since 1950 there have also been scattered outbreaks in Western Australia. The basic cause has still not been discovered, but the problem is at present under investigation (see Bennetts 1957, 1959,

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1960).) Despite lupinosis the area under lupins in Germany was still more than 300,000 hectares at the turn of the century (Hackbarth and Husfeld 1939).

The cheapness of artificial nitrogen fertilisers caused a decline in lupin growing just before the first world war, but there was a renewal of interest in the early 1920's, when methods were devised for extracting the alkaloids from seeds on an industrial scale, paving the way for their use in rations for stock other than sheep. The process was fairly costly however, and with the difficulty encountered in harvesting because of rapid seed-shedding at maturity, it became uneconomic when the price of imported feeds fell in the late 1920's.

The Sweet Lupin

About the same time, the question was raised as to whether it might be possible to select alkaloid-free strains. This had been suggested by Roemer as early as 1916. A search was started by von Sengbusch in 1927, and by 1929 he had succeeded in finding 5 plants virtually free of alkaloids among the 1.5 million plants which were individually tested. Three were of *L. luteus* and two of *L. angustifolius*. These stocks were increased as quickly as possible, and in 1934 the Seed Production Company (S.E.G.) of Berlin was able to put 140 tons of seed on the market (Hackbarth and Husfeld 1939).

The private nature of this venture and the secrecy involved caused some rumblings in Russia, where there was also considerable interest in the possibility of breeding alkaloid-free lupins (Vavilov 1932). Independent efforts were set in motion and these were successful in isolating alkaloid-free strains of *L. luteus* (Fedotov 1934) and *L. angustifolius* (Svirskii 1934). However, later Russian work seems to have been concerned mainly with introduced German material.

The original "sweet lupins" (*Süsslupine* was the trade name adopted for the alkaloid-free strains) suffered a number of disabilities besides those stemming from their greater palatability to stock, wild animals, and some insect pests. Like the bitter strains they had a tendency towards hard-seededness, and shed their seeds very readily, making harvesting difficult.

Despite this, the area sown to sweet lupins expanded rapidly, reaching 78,000 hectares in 1938 but declining again somewhat during the war (Hackbarth and Troll 1957).

German breeding work since 1930 has been concerned largely with searching for non-shedding and soft-seeded strains, and in recent years also with achieving greater earliness and disease resistance. The work to date has been summarised by Hackbarth and Troll (1957) and is well documented in the German literature. Breeding has also been undertaken in Holland, Sweden, and Poland, as well as Russia, and more recently in South Africa, the United States, New Zealand, and Australia. In Poland, Barbacki has been working with lupins since the 1920's, first at Pulawy and latterly at Poznan. According to Hudson (1958) the Polish lupin work is now on a very considerable scale. Judging by the titles of papers in the literature, there is also a good deal of interest in lupins in western Russia.

The search in Germany for a non-shedding strain of *L. luteus* was rewarded in 1935 when a mutant was found in which the pods remained without splitting for some time after maturity. A soft-seeded strain was isolated about the same time. Meanwhile in 1932 a white-seeded mutant had been discovered in the original alkaloid-free stock of *L. luteus* ("strain 8") and had been multiplied as a separate variety under the name "Weiko". These three characters and "sweetness" itself were all found to be due to simple recessive genes, which facilitated their bringing together into a single alkaloid-free, soft-seeded, white-seeded, non-shedding variety. The first such variety was released in 1943 as Weiko II.

A further useful mutant (also recessive) was discovered in *L. luteus* by Hackbarth in 1938, characterised by more erect and rapid growth in the early stages and slightly earlier maturity. By combining this character with the desirable ones of Weiko II, the variety Weiko III was obtained. It was first released in Germany in 1951 and has since become the leading commercial alkaloid-free variety in that country. It is also considered the best variety in England (Anon. 1957) and has shown promise on sandy soils in Western Australia (Gladstones 1958*b*, 1959). A very similar

variety is grown in the Cape Province of South Africa under the name Stellenbosch-Elzenburg Geel No. 1.

The alkaloid-free varieties of *L. angustifolius* have not received as much attention as those of *L. luteus*, partly because the species is not adapted to quite such poor acid soils as *L. luteus*, and partly because no truly non-shedding strain has yet been found. However it does not normally shed its seed quite as readily as the older varieties of *L. luteus*, and under suitable conditions it is capable of very rapid and prolific growth and high seed yields. The Swedish-bred variety "Borre", which unlike the original German varieties is fully soft-seeded, is probably the most widely popular alkaloid-free variety of *L. angustifolius*. It has given good results in New Zealand (van Steveninck 1956), Western Australia (Gladstones 1958*b*, 1959), and in the Gulf Coast States of the U.S.A. (Henson and Stephens 1958).

A good deal of attention is now being given to *L. albus*, which although it needs reasonably fertile loamy soils is capable of excellent seed yields under suitable conditions. Alkaloid-free strains were isolated during the 1930's and the cultivated bitter varieties are already soft-seeded and non-shedding. Reasonably early-maturing varieties are now available. Present work is concentrated mainly in Germany and Poland (see Barbacki *et al.* 1955; Hackbarth 1956, 1957*a*; Hudson 1958) and is concerned particularly with obtaining still earlier varieties which will give reliable results under Northern European conditions. The original Mediterranean bitter varieties are late-maturing.

Other species in which alkaloid-free varieties have been selected are *L. mutabilis*, which is of some interest on account of its high seed oil content, and *L. perennis* and *L. polyphyllus*. The latter species are perennials which are believed to hold possibilities for northern areas in Russia because of their frost resistance, early maturity, and tolerance of acid soils (Levin 1947; Hudson 1958).

Commercial Lupin Growing in Europe

The main lupin area is in north-eastern Europe, from about Berlin eastwards through East

Germany, Poland, and western Russia, on the acid podsollic soils characteristic of this region. According to Hackbarth (1957*b*) the area grown for seed in Poland in 1952 was about 170,000 hectares, and probably increasing. Hudson (1958) reported intense interest in lupins among Polish plant-breeders, and attributed it to the large areas of sandy soils in many parts of Poland, and the shortage of fertilisers.

Little information is available about the area of lupins grown in Russia. Hackbarth (1957*b*) believes it to be considerable, and mainly in the west between latitudes 51° and 55°N. Fedotov (1946) proposed that perennial varieties should be grown in the northerly part of European Russia, with *L. angustifolius* to the south of these between 57° or 58°N and the southern boundary of the Byelo-Russian S.S.R. *L. luteus* and *L. albus* were recommended for areas further south again, and the latter species also for the sub-tropical zone and the Maritime Province on the Pacific coast. Maisurjan and Filatov (1956) say that sowings of sweet lupins for seed are concentrated mainly in the western and south-western parts of the non-chernozem belt, and that the main obstacle in their wider use in the U.S.S.R. is poor seed production.

Lupins are also grown in Hungary. Sváb (1959) describes experimental work there, which is concerned mainly with non-shedding strains of *L. luteus* for light soils in the hilly districts of the north-east.

The scale of lupin growing in West Germany is limited, partly because of the lesser incidence of sandy soils. The main areas, according to Hackbarth (1957*b*), are the Lüneburg Heath, between Hamburg and Hanover, and the Emsland, in the extreme west.

Much of Holland is clearly unsuitable for lupin growing, but there are areas of sandy waste land in the south and adjacent the German border where sweet lupins have proved valuable. Owing to the humid climate, fungal diseases are a serious problem in Holland, and breeding work, which is under the charge of Dr. H. Lamberts at Wageningen,

has been concerned especially with breeding disease-resistant varieties.

Sweet lupins were early introduced into Sweden, where much research has been done on their growing and utilisation. Winkler *et al.* (1956) describe experiments with *L. luteus* and *L. angustifolius* for silage making, but note that although both species grow well in districts with sandy soils they are too late maturing for reliable seed production. As a result, lupin growing is limited by shortage of seed and its high price. There are similar reports from West Germany and Holland, where the danger of wet conditions at ripening makes seed production hazardous. The seed position has been aggravated by contamination of sweet lupin stocks by bitter varieties.

Lupin growing has never become widespread in England, although for about 100 years bitter varieties have been included in the rotation on some of the poor glacial sands of Suffolk, where they grow very well. Lupin cultivation in England is described by Oldershaw (1925) and Pieters (1927). There has since been some small-scale cultivation of sweet varieties (Oldershaw 1944, 1951) and more recently the Weiko III variety has given good results, although seed production is not recommended except in the south-east (Anon. 1957). The limited areas of soils in England suitable for lupins will probably prevent their extensive use.

The growing of *L. albus* in Mediterranean countries has already been mentioned. Von Sengbusch (1938) believes the area sown annually as a grain crop in Italy, Spain, and Portugal to be of the order of 300,000 hectares, mostly in Italy. Hackbarth (1957*b*) mentions that during the last few years experiments on seed production of sweet varieties, prompted by the seed shortage in Northern Europe, have met with some success in parts of the Western Mediterranean, notably in Portugal and Southern France, but not so far in Italy.

Africa

L. albus is grown to some extent in the Nile Valley, as it probably has been for thousands of years. Bacon (1948) estimates that the annual production in the Sudan is about 2,000 tons. "The seed, which stores indefinitely, is bitter

and poisonous until boiled and strained, when it is very nutritious and relished as an item of local diet".

Both bitter and sweet varieties have been found to flourish in the Cape Province of South Africa. Eksteen and Beyers (1958) write: "Since 1940 there has been a very rapid development in the winter rainfall area in the cultivation of lupins, both as a green manure crop for orchards and vineyards, and as a fodder crop in rotation with cereals. Today there is hardly an orchard or vineyard without a cover of lupins during the winter months, and there are few grain farms where the lupin is not used as a fodder crop". There have, however, been some cases of lupinosis (Flight 1956). The main variety referred to here is bitter *L. angustifolius*. Lately there has been much interest in the alkaloid-free, non-shedding varieties of *L. luteus* as high protein grain legumes for stock feed. Feeding trials are reported by Swart and Leibenberg (1954), Swart (1955), and Vosloo, van der Vyver and Steenkamp (1955).

Alkaloid-free lupins are also recommended for growing in Kenya at altitudes of 5,000 to 8,000 feet (Strange 1955). In Southern Rhodesia, Williams (1953) describes sweet strains of *L. luteus* and *L. angustifolius* as thriving exceptionally well on acid, sandy soils at Melsetter (altitude about 6,000 feet).

South America

The native species *L. mutabilis* has long been grown as a minor crop in the Peruvian and Bolivian Andes, where it is known as "tarhui" (Herrera 1944, Burkart 1952). According to Burkart, the seeds are steeped to remove alkaloids and used for food in the same way as *L. albus* in Mediterranean countries. Von Sengbusch (1953) believes that *L. mutabilis* has been cultivated for several thousand years, and that it ranks with *L. albus* in antiquity as a crop plant.

There is also some cultivation of lupins in Argentina, where bitter *L. albus* is grown both as green manure and for grain for human consumption. According to statistics quoted by Burkart (1952) the area grown in 1942 was 6,650 hectares, mainly in the north-east from La Plata and Buenos Aires to Corrientes, and

on the western slopes of the Andes in the north-west. Boerger (1939) noted that *L. albus* grows well in Uruguay and that trials were being made there with sweet lupins as a winter forage crop. Corrêa (1939) describes experiments with lupins in South-East Brazil (Rio Grande do Sul) and highly recommends their use for green manure. He found *L. albus* and *L. angustifolius* to be better adapted to the soils there than *L. luteus*.

North America

Mediterranean species of lupins were introduced into North American agriculture as recently as 1939 (Decker, Webb and Edwardson 1953). They have already become quite an important crop in the Gulf Coast States, where they are grown on sandy soils as a winter green manure crop. The area planted had reached about 60,000 acres by 1944 and 200,000 acres by 1945, according to McKee and Ritchey (1947). Henson and Stephens (1958) state that the average annual seed production for the 10-year period 1946-55 was 54 million lb, or enough to plant half a million acres, but only 15 and 17 million lb in 1956 and 1957. About 75 per cent. of the seed crop is of bitter *L. angustifolius*. *L. luteus* is confined almost entirely to Florida, and seed production is limited by virus disease, which under Florida conditions is found to be partly seed-transmitted (Corbett and Edwardson 1957). Virus-free seed of Weiko III is imported from Germany. Virus diseases are not a serious problem with *L. angustifolius*, which is grown in Northern Florida and the southern parts of Louisiana, Mississippi, Alabama, Georgia, and South Carolina. Georgia is the most important state, producing two-thirds of the seed crop (Henson and Stephens 1958). A small area of *L. albus* is grown along the northern fringe of the lupin belt.

During the last few years alkaloid-free varieties have become popular for winter grazing, especially for fattening cattle. The variety Borre (*L. angustifolius*) has given consistently good results in Southern Georgia, and Weiko III is favoured in Florida.

Proebsting (1958) notes that lupins have been successful as a green manure crop in limited areas in California. He does not specify

what species is used.

There have been some trials with spring-sown lupins in northern states of the U.S.A. Stockeler (1957) describes experiments with lupins for cover cropping in forest nurseries in Northern Michigan and Wisconsin. Several species gave good results but *L. luteus* was consistently the best. The same author (1958) has published preliminary observations on the use of perennial lupin species for this purpose. Henson and Stephens (1958) state that "attempts to grow lupins in the Northern United States as a spring-planted, full season crop have been successful in limited areas", but that "additional trials are needed before definite recommendations can be made".

New Zealand

It is not certain how long lupins have been cultivated in New Zealand, but a bitter variety of *L. angustifolius* has been grown there for many years, mainly on the Canterbury Plains of the South Island for sheep feed. Until recently all seed of this species used in Australia was imported from New Zealand: hence the popular name, New Zealand blue lupin.

An alkaloid-free variety of *L. angustifolius* was released in New Zealand in 1942 (Black and Claridge 1942) but it was hard-seeded and met with little success. Much better results have been obtained with the soft-seeded variety Borre, which has now been released to farmers (van Steveninck 1956). This has proved useful for fattening lambs, often in a mixture with other forage species such as rape (Greenall 1956). *L. luteus* seems to have been less successful.

Western Australia

The origin of lupins in Western Australia is not known. They are believed to have been introduced into the Geraldton district about 1860 or 1865. There is some evidence that they may have been grown at the convict settlement at Lynton, on the coast about 40 miles north of Geraldton, possibly for food.

Probably lupins were first introduced into the State as ornamentals. The species known as the West Australian blue lupin escaped from cultivation and within a few years was well established in the Geraldton district as a weed.

This species, which has previously been known in the Australian literature as either *L. varius* L. or *L. pilosus* L. has now been identified as *L. digitatus* Forsk. (Gladstones 1958a). It is described by Gardner and Elliot (1929).

Both *L. digitatus* and *L. angustifolius* were common in the Swan Valley, near Perth, by the 1880's and perhaps even earlier, and the former species at least is known to have been present as a weed at Australind and Donnybrook by 1890.

Although farmers at first thought lupins to be poisonous, it was soon found that sheep thrived on the dry plants and fallen seeds during the summer. The date of this discovery is uncertain, but it is recorded that a Mr. Hazelden fattened 200 sheep on a paddock of pure lupins near the Geraldton racecourse as early as 1894. By 1910 lupins were being widely planted in the Geraldton district, and by 1920 in the Gingin and Dandaragan districts, 50-100 miles north of Perth.

The coastal plain between Perth and Geraldton has remained the main centre of cultivation of *L. digitatus*. The species thrives on deep, slightly loamy sands. Grazing of the fallen seeds and leaves takes place from the time the plants mature (November) until the first autumn rains in April or May. Ample seed is usually trodden into the ground to provide for natural regeneration. With their high protein content (30-35 per cent.) the seeds form a valuable supplement to the associated dry annual grasses, which tend to be very deficient in this respect.

L. angustifolius was first used as a green manure crop in vineyards in the Swan Valley and in apple orchards around Donnybrook about 1930, and its popularity for this purpose on light soils grew rapidly. At first all seed was imported from New Zealand, but local seed production began at Donnybrook in 1945 and has since spread to the Bridgetown and Boyup Brook districts. Production is now ample for all local needs. The use of *L. angustifolius* for sheep feed, in the same way as *L. digitatus*, has also become popular in these districts since about 1945. The lupins are commonly sown

on newly cleared land to act as a pioneer legume, giving way to more permanent subterranean clover-grass pastures after two or three years.

The first experimental work with lupins in Western Australia was reported by Thomas (1924) and Thomas and Shier (1925). A wide range of introduced species and varieties was grown for observation at the Chapman and Merredin research stations of the State Department of Agriculture. Later, *L. digitatus* was included in rotation trials at the Chapman and Wongan Hills research stations.

After the introduction of subterranean clover into the wheat-belt, most of the work with lupins lapsed, although their use in districts between Perth and Northampton continued to expand, largely on light land where clover establishment was found to be difficult or impossible.

Despite generally unfavourable indications from earlier research, a new investigation into the commercial possibilities of lupins was started in 1954 by the Institute of Agriculture, University of Western Australia, as part of its soil fertility research programme. It was felt that the known adaptation of lupins to poor sandy soils made them of great potential value to W.A. In addition, the improved alkaloid-free varieties then being bred in Europe opened up much wider possibilities of utilisation than had been the case before.

As a result of this work, two introduced alkaloid-free varieties, selected as being suitable for trial on a commercial scale, have now been released to farmers. These are Borre (*L. angustifolius*) and Weiko III (*L. luteus*). The latter is of particular interest on account of its non-shedding habit, high seed protein content (about 40 per cent.) and tolerance of poor soils, making it potentially valuable as a grain legume. Borre should succeed in the South-West of W.A. where annual rainfall is 16-18 inches or more. For the present, Weiko III is only being recommended for districts with an annual rainfall of 18-20 inches or more. The investigation is reported in detail elsewhere (Gladstones 1958b, 1959).

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PASTURE LEGUMES IN TASMANIA

The Tasmanian Branch of the Australian Institute of Agricultural Science held a Symposium, "Pasture Legumes in Tasmania," in Launceston on October 29, 1959.

Four of the papers presented at the Symposium are published here.

THE LEGUME-RHIZOBIUM SYMBIOSIS

J. F. LONERAGAN

In this review the discussion of the legume-*Rhizobium* symbiosis will be confined within the scope of the symposium and will deal only with those legumes of agricultural importance in temperate Australia.

Legumes assume extreme importance in Australian agriculture because of their ability to use atmospheric nitrogen. However, legumes can only fix nitrogen when they have developed a highly specialised association with specific bacteria. Without the nodule bacterium, or *Rhizobium*, the legume can grow quite happily but can not use atmospheric nitrogen. The *Rhizobium* can also grow freely in soils but likewise can not fix nitrogen on its own. Together the legume and *Rhizobium* can fix astounding quantities of atmospheric nitrogen—figures of up to 500 lb of nitrogen per acre per year have been estimated (see Russell 1950). This is equivalent to a fertilizer dressing of 21 cwt of ammonium sulphate per acre per year. The amount of nitrogen fixed by legumes in Australian pastures is probably much less than this figure, but still very high. For example, a virgin soil in the Adelaide hills

under a subterranean clover-phalaris pasture treated with 2 cwt of superphosphate per acre each year improved by 382 lb of nitrogen per acre over a three year period (Trumble and Donald 1938).

Here then we have two organisms which may live independently but which can only use atmospheric nitrogen for their growth when associated in an intimate symbiosis. The first stage in the symbiosis in *Trifolium* (see Nutman 1958) is the multiplication of nodule bacteria in the neighbourhood of the root of the legume. This is followed by a curling of the root hair. The next step can only proceed if the host and the strain of *Rhizobium* present are compatible. This step is infection of the root hair with development of an infection thread. The thread grows within the root hair, through the cells of the cortex, and stimulates cell division in a centre of tetraploid cells. These tetraploid cells, together with surrounding diploid cells eventually grow into the

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nodule. Within the tetraploid cells the bacteria multiply and become swollen, forming bacteroids. After the formation of bacteroids, nitrogen fixation may proceed.

Thus symbiotic nitrogen fixation depends upon the successful establishment of a complex union between two free living organisms. This makes it particularly vulnerable to adverse environmental conditions. To understand the effects of environmental conditions upon symbiotic nitrogen fixation, it is useful to consider their effects upon four clearly distinct phases of the process. Firstly, an efficient symbiosis depends upon healthy growth and metabolism of the host legume. Secondly, environmental conditions must be suitable for growth of the specific strain of *Rhizobium* able to nodulate the host. Thirdly, conditions must be suitable for development of the symbiosis between the legume and the *Rhizobium*. Finally, conditions must be suitable for the symbiosis to function efficiently.

Any environmental condition which restricts any one of these four phases of the symbiosis must restrict the amount of nitrogen fixed. The rest of this review will be devoted to a discussion of this principle by presentation of examples of some peculiar environmental requirements of each of the phases outlined. Where possible examples from work on the effects of calcium nutrition and of acidity, with which I have been associated, will be used.

Growth and Metabolism of the Host Plant

Any condition which affects growth of the host plant will at the same time affect the amount of nitrogen fixed. For example, in an experiment with subterranean clover, calcium deficiency decreased the amount of nitrogen fixed from 220 to 20 lb of nitrogen per acre in the tops alone (Loneragan 1959). This was due entirely to an effect of calcium deficiency on the growth of the host plant, since addition of fertilizer nitrogen gave no better growth of the calcium deficient plants. In fact, the calcium deficient plants contained a higher percentage nitrogen than those which fixed eleven times as much nitrogen. A similar situation has been described for soybean (Horner 1936; Albrecht 1937).

Many other nutrient deficiencies may behave in a similar fashion, e.g. zinc (Mulder 1948), sulphur (Anderson and Spencer 1950), boron (Mulder 1948), copper (Hallsworth 1958), potassium (Blaser and Brady 1950), phosphorus (Trumble and Shapter 1937). Other environmental factors may also affect the amount of nitrogen fixed by influencing the growth of the host plant, e.g. light, moisture, and temperature (van Schreven 1958); competition from non-legumes and nitrogen status of the soil (Trumble and Shapter 1937); aluminium toxicity (Rorison 1958).

In addition to restricting nitrogen fixation by restricting growth, some environmental conditions may also reduce the amount of nitrogen fixed by disturbance of the nitrogen metabolism of the host plant. Subterranean clover deficient in sulphur, for example, has been observed to appear nitrogen deficient and to have a low percentage nitrogen. However, these plants failed to respond to fertilizer nitrogen. Sulphur was shown to be required for the conversion of non-protein nitrogen to protein and not for the process of nitrogen fixation (Anderson and Spencer 1950). Nevertheless, symbiotic nitrogen fixation was greatly reduced by sulphur deficiency.

Environmental conditions which limit nitrogen fixation through effects on the growth and metabolism of the host plant are characterised by the failure of the legume to respond to the addition of fertilizer nitrogen. These conditions may affect the growth of grasses given adequate nitrogen and of legumes to the same degree. On the other hand the legume may have a special requirement or may be less able to satisfy its requirement than the grass. For example, there is some evidence that some legumes, such as lucerne, may be less able to take up calcium than other plants and are particularly susceptible to calcium deficiency on acid soils (Schmehl *et al.* 1952). On the other hand I have found that subterranean clover has a high capacity to obtain its calcium requirements from low calcium, acid soils. Phosphorus provides another example. The importance of phosphorus in the nutrition of subclover is well known and is of the highest practical importance in Australia (Trumble and

Shapter 1937; Anderson and McLachlan 1951). In this case sub-clover is less able to obtain its phosphorus requirements from soils low in phosphorus than grasses such as Wimmera Rye. Other examples of special nutrient requirements for legumes are zinc for the nutrition of sub-clover, copper for lucerne (Riceman 1948), and potassium for white clover (Blaser and Brady 1950).

Rhizobium Survival and Growth

We have been discussing the conditions which affect growth of the host legume. For nitrogen fixation to take place it is obviously just as important that the *Rhizobium* should be able to survive and grow in the soil. The conditions required for growth of these two organisms—the *Rhizobium* and the legume—may be similar or they may be quite distinct. In addition there may be considerable variation in the conditions required for the group of different individuals within each group of organisms. Many conditions may of course limit *Rhizobium* growth. All of these are important for growth of *Rhizobium* in culture, but for growth of *Rhizobium* in the soil only those conditions to which the *Rhizobium* is more sensitive than any other phase of the symbiosis will be important.

The differential effects of acidity on the growth of *Rhizobium* and of subterranean

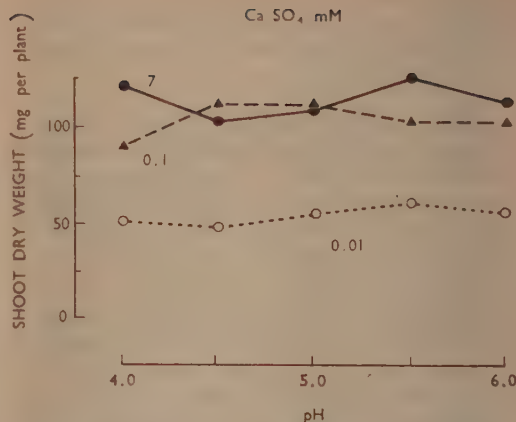


Figure 2—Effects of pH and calcium on growth of "Bacchus Marsh" subterranean clover.

clover provide a good example of this principle. In another paper in this Symposium Mr. Paton discusses some of the problems of nodulation on acid soils in Tasmania. Where this problem occurs on the Southern Tablelands of N.S.W. (Anderson and Moye 1952) it has been shown to be due to an effect of soil acidity on growth of *Rhizobium* (Anderson 1956). A change in soil acidity involves more than a simple change in hydrogen ion concentration (Hewitt 1952). However, we have been able to show that the difference in behaviour of *Rhizobium* and host to hydrogen ion concentration alone is sufficient to explain the nodulation problem on acid soils. We have used water culture to study the effect of acidity on the growth of subterranean clover and on the growth of *Rhizobium*. (Loneragan and Dowling 1958). Figure 1 shows the effect of changing pH on the growth of *Rhizobium*: the *Rhizobium* was very sensitive to acid conditions and made little or no growth at pH 4.0 or even 4.5. Figure 2 shows the effect of changing pH on the growth of subterranean clover: the clover was not effected by acidities which stopped the growth of *Rhizobium*. Clearly then subterranean clover may flourish in a soil which is sufficiently acid to stop the growth of its *Rhizobium*.

Recently there has been a suggestion that magnesium may be important in problems of nodulation of legumes (Norris 1958, 1959).

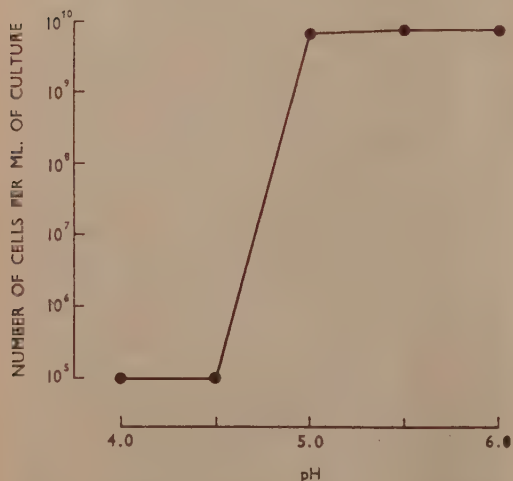


Figure 1—Effect of pH on growth of *Rhizobium trifolii* Strain NA 30.

This suggestion is based on the demonstration that *Rhizobium* requires magnesium for growth: unfortunately no attempt has been made to assess the reaction of the host to magnesium under the same conditions. Therefore, unless the *Rhizobium* requirement of the magnesium happens to be less easily satisfied than that of the host plant, a response of *Rhizobium* to magnesium will only be obtained under conditions where the plant can't grow anyway. Since this critical evidence is lacking there is no more reason to implicate magnesium in nodulation problems than to implicate any of the other fifteen or so inorganic nutrients which *Rhizobium* requires for growth.

Competition of other organisms in the rhizosphere has also been suggested as a problem in the survival of *Rhizobium*. This competition may be between the *Rhizobium* and an ineffective strain of *Rhizobium* (Harris 1954) or other micro-organisms (Hely *et al.* 1957; Cass Smith and Holland 1958). Toxicities of seed insecticides and of fertilizers, superphosphate acidity, ammonium sulphate acidity, copper, and zinc may also kill *Rhizobium* being introduced to soil while leaving the host unharmed (see review by Vincent 1958).

Rhizobium is known to excrete vitamin B₁₂ which contains cobalt (Levin *et al.* 1954). This suggests that a specific effect of cobalt on *Rhizobium* growth may yet be established.

For some time calcium was thought to be required in large amounts by *Rhizobium* (McCalla 1937; Norris 1956). However, we have been able to show that the calcium requirement of the NA 30 strain of *Rhizobium* is far less than that of the host subterranean clover (Loneragan and Dowling 1958). Figure 2 shows that the growth of subterranean clover was markedly depressed at a calcium concentration of 0.01 mM. Using the same medium we were able to get maximum growth of *Rhizobium* without adding any calcium. Apparently the small amount of calcium in the yeast extract was sufficient for growth of *Rhizobium*. These results have recently been confirmed for a large number of *Rhizobium* strains (Norris 1958; Norris 1959).

It is convenient at this stage to turn to the third phase in the development of the symbiosis.

Nodule Formation

It is convenient because we may start with the example of the effect of calcium on the formation of nodules while the effects of calcium on the growth of *Rhizobium* and of sub-clover are still fresh in our minds.

Subterranean clover requires more calcium for nodule formation than it requires for its own growth when supplied with nitrogen (Loneragan and Dowling 1958). Figure 2 shows that increasing the calcium concentration from 0.1 mM. to 7 mM. had no effect on the growth of the sub-clover at any pH. Figure 3 shows the effect of the same treatments on the nodulation of the same plants.

At pH 4.5 increasing the calcium concentration from 0.1 mM to 7 mM increased nodulation from 0 to 10 nodules per plant. Clearly, calcium had a marked effect on nodule formation at a level which affected neither plant nor *Rhizobium* growth. This effect of calcium on nodule formation disappeared at pH 6.0; but the plants grown at 0.1 mM calcium contained more calcium at pH 6.0 than at pH 4.5, thus lending support to the view that the level of calcium in the plant itself is critical for nodule formation. This extra calcium may be needed in the actual development of the nodules. However, it is still possible that plant calcium might affect the growth of *Rhizobium* by influencing the excretion of organic substances from the plant.

Boron deficiency has been shown to interfere quite specifically with nodule development.

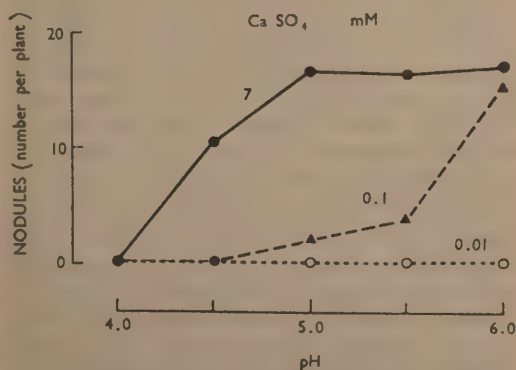


Figure 3—Effects of pH and calcium on the nodulation of "Bacchus Marsh" subterranean clover.

Under some conditions vascular strands fail to develop in the nodules of boron deficient plants (Brenchley and Thornton 1925).

Many strains of *Rhizobium* are also known to be ineffective in nitrogen fixation because they fail to complete a step in nodule development (see Bergerson 1957). Nodule development may also be specifically affected by light, temperature, or combined nitrogen (see review by Nutman 1956).

Functioning of the nodule

Here we are concerned with those factors which specifically affect the process of nitrogen fixation in the structurally complete nodule. These factors may be distinguished from the factors affecting the growth of the host plant by the symptoms of nitrogen deficiency in the host, and by improved growth of the host plant on addition of fertilizer nitrogen.

Calcium nutrition of subterranean clover may again be taken as an example. We have seen that under conditions of acute calcium deficiency, the amount of nitrogen fixed by the host plant may be limited entirely by restriction of the growth of the host plant. However, under conditions of moderate calcium deficiency there may be a specific effect of calcium deficiency on the fixation process itself (Lonergan 1959). This situation is illustrated in Figure 4, which shows the effect of fertilizer nitrogen on the growth of subterranean clover at different levels of calcium.

Where the calcium supply is adequate there is no response to nitrogen. Where calcium deficiency is acute there is again no response to nitrogen, but at an intermediate supply of calcium there is a marked effect of nitrogen on the growth of the host plant. Thus subterranean clover requires more calcium for nitrogen fixation than it does for growth of the host plant and in this situation the amount of nitrogen fixed by the host is limited by a restriction on the process of nitrogen fixation. This conclusion is supported both by the appearance of the plants and by their nitrogen content. Plants given an intermediate supply of calcium and no nitrogen were yellow as if nitrogen deficient. They also contained a lower percentage protein and percentage non-protein

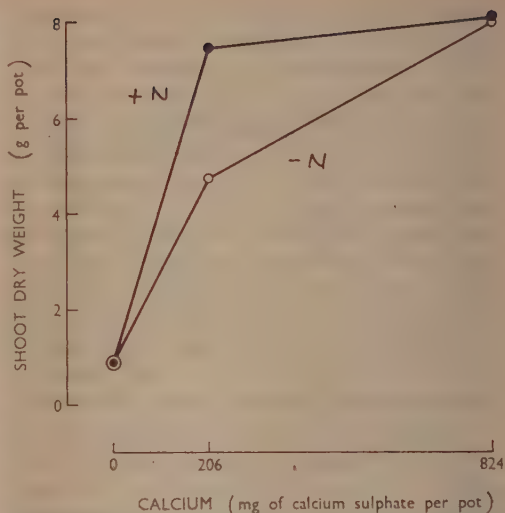


Figure 4—Effect of calcium on the growth of "Bacchus Marsh" subterranean clover in the presence and absence of fertilizer nitrogen.

nitrogen than either the controls or the acutely calcium deficient plants.

Recently it has been suggested that copper may limit the amount of nitrogen fixed by legumes through a specific effect on nitrogen fixation (Hallsworth 1958). At low levels of nitrogen, copper deficiency decreased both growth and percentage nitrogen of subterranean clover plants. Application of nitrogen increased both the percentage nitrogen and the growth of these copper deficient plants. However, application of nitrogen increased growth of the high copper plants to an even greater extent. Hence the evidence that copper participates in the functioning of the nodule although suggestive is not conclusive.

The evidence that legumes require more molybdenum for nitrogen fixation than for growth is now firmly established (see review by Anderson 1956).

There is also evidence that a number of other factors may limit the amount of nitrogen fixed by legumes by specifically inhibiting the efficient functioning of the nodule. Some of these are:— ineffective strains of *Rhizobium* (Bergerson 1957), combined nitrogen (see review by Nutman 1956), and temperature (Meyer and Anderson 1959).

Cobalt may yet be found to be involved in this aspect of nitrogen fixation since the nodules of some legumes have been shown to contain vitamin B₁₂ (Bertrand and Wolf 1954; Levin *et al.* 1954).

General Conclusion

Efficient nitrogen fixation by legumes has been shown to depend upon favourable environmental conditions for some four distinct phases of the legume-*Rhizobium* symbiosis. An understanding of the effects of environmental conditions upon these phases of the symbiosis is of considerable help in recognising and correcting field problems of legume establishment and growth.

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PROBLEMS IN LEGUME ESTABLISHMENT WITH SPECIAL REFERENCE TO NODULATION AND NUTRITION

D. F. PATON

During the past 12 years the area sown to improved pastures in Tasmania has more than doubled—from just over 600,000 acres in 1948 to almost 1,300,000 in 1959.

Much of this expansion has occurred on the poorer class soils of the state. These soils are invariably acutely deficient in both nitrogen and phosphorus and often in other plant nutrients. Frequently they are also moderately to strongly acid in reaction.

The development of these areas is based on the establishment of a vigorous stand of white and subterranean clover—usually in association with perennial ryegrass—to raise the nitrogen status of the soil as quickly as possible to a level where it will support satisfactory pasture production. Successful establishment of the sown legumes must therefore be regarded as a first essential in the development of these poor soil areas.

In many cases however, poor clover establishment is obtained when the conventional methods, known to give good results on the less difficult soils of the state, are used. Investigations carried out on many of these problem areas have shown that in practically all cases, this poor establishment is due either to defective nodulation or incorrect nutrition or both.

Nodulation Problems and the Use of Seed Inoculation

Difficulties in clover establishment due to poor nodulation have been recognised on several Tasmanian soils for many years. However, only during the past six years following the isolation and use of effective *Rhizobium* strains,

has any significant progress been made in understanding and overcoming them.

In the period up to 1953, nodulation problems were recognised as being of two types.

On the strongly acid soils (pH* less than 5.2) poor nodulation of the clovers with very high seedling mortality—usually resulting in the total failure of the sown species—was invariably obtained in the absence of lime. On many areas, broadcast applications of lime at 1 ton per acre before sowing overcame this problem, but on others the clovers were still slow to “make up”. Seed inoculation with the standard *Rhizobium* culture then available had no effect.

Poor nodulation resulting in patchy growth of clovers was also frequently observed during the first year or so after sowing on the less acid soils (pH more than 5.2). With annual applications of superphosphate, growth of clovers on most of these areas steadily improved until, by the end of the second or third season, a satisfactory stand was obtained. Lime improved the establishment on some of these areas, but not on others. No responses were recorded to seed inoculation.

The patchy growth and slow development of the clovers which commonly occurred during the first few years of pasture establishment and

*All pH's quoted were determined on a 1:5 soil:water suspension.

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which were not corrected by any fertiliser, inoculation or cultural treatment, had by 1953, come to be accepted as a normal phase in the development of many new areas.

In 1953 however, during the course of investigations into the reasons for poor clover establishment on a north east coast soil, a spectacular improvement in clover establishment was obtained following inoculation with a recently isolated, local strain of *Rhizobium*. Subsequent work showed that the strain of *Rhizobium* used previously in Tasmania was relatively ineffective and that using effective strains, significant responses to inoculation of both white and subterranean clover could be obtained at a number of centres throughout the State. (Paton 1957). It has since been shown that on many of the areas with a history of slow legume development, rapid and satisfactory establishment can now be obtained when effective seed inoculation techniques are used.

Interactions of Seed Inoculation and Lime

A feature of the more recent work has been the inter-relationships found between effective seed inoculation techniques and the need for lime. On many soils seed inoculation has either completely or partially replaced the conventional dressing of lime ($\frac{1}{2}$ to 1 ton per acre broadcast), but on the others heavy lime in addition to seed inoculation is still required. These different interactions between seed inoculation and lime have been found to be closely associated with soil pH.

In this work, superphosphate at 3 cwt per acre—or lime-superphosphate mixtures at equivalent rates of phosphorus—has been applied to correct the general phosphorus deficiency. These dressings would also supply significant amounts of calcium.

Lime Essential

On the strongly acid soils (pH less than 5.2) some lime, in addition to seed inoculation and molybdenum, is invariably required when sowing clovers on new areas. On these soils heavy dressings of ground limestone—e.g. 1 ton or more per acre—broadcast on the seed bed before sowing and worked in with the seed, have given good establishment on most areas investigated.

Using superphosphate as the source of phosphorus, heavy applications of lime are still required for satisfactory nodulation and growth on the very acid soils (pH less than 4.8). However, on many of the less acid soils of this group (pH 4.8 to 5.2), smaller quantities of lime placed in contact with the seed at sowing have given satisfactory results. The conditions under which these various methods have been found effective in Tasmania are as follows.

Seed Drilled with light rates of lime

Anderson and Moye (1952) found that in the presence of molybdenum, drilling inoculated seed with 2 cwt per acre of ground limestone gave good establishment of subterranean clover on acid soils in New South Wales.

The method has now been tested on a number of Tasmanian soils, frequently with good results. This applies particularly to many of the acid sandy soils at present being developed on Flinders Island and along the north east coast. In these instances, inoculated seed drilled with 3 cwt per acre of ground lime and with the superphosphate broadcast as a separate operation, has given results at least equivalent to 1 ton per acre of lime broadcast.

Soils on which this method has been unsatisfactory are some of the strongly acid basalts and the very strongly acid (pH less than 4.8) leached sands. Inefficient utilisation of the applied phosphate, due apparently to high phosphate fixation, is considered to be the main reason for the poor results recorded with this method on the basaltic soils. On the strongly acid sands, satisfactory nodulation but very poor growth has been obtained. The significance of this effect is discussed subsequently.

Lime-Superphosphate Mixtures

Drilling inoculated seed with two lime-superphosphate mixtures, namely 1:1 ground lime-superphosphate and basic superphosphate (15 per cent. air-slaked lime) has generally given results similar to those obtained by drilling the seed with lime and broadcasting the superphosphate separately, provided equivalent amounts of phosphorus are applied. An exception has been some acid basaltic soils on which basic superphosphate has given improved establishment and growth compared with drilling the seed with either lime or superphosphate.

Due however, to the practical difficulties of mixing and then drilling the heavy rates of mixture required—e.g. 5-6 cwt per acre of the 1:1 mixture—the technique of drilling the seed with 2-3 cwt per acre of lime and broadcasting the superphosphate separately is generally favoured for most Tasmanian soils.

Lime Coated Seed

Loneragan *et al.* (1955) reported improved nodulation and growth of subterranean clover where seed was coated with lime after inoculation.

Lime coated seed has now been tested on a number of soils in Tasmania, but with variable results. Generally, the method has not been successful on the strongly acid soils, although on some of the less acid areas, good establishment has been obtained. These effects are discussed in more detail in later sections.

Heavy Broadcast Applications of Lime

On many strongly acid soils small quantities of lime sown in contact with inoculated seed—e.g. lime coated seed or seed drilled with 2-3 cwt per acre of ground limestone—have given satisfactory nodulation but very poor growth relative to heavy broadcast applications of lime—e.g. 1 ton per acre. Molybdenum has not improved growth in these cases.

In investigational work on several strongly acid sands, symptoms of acute phosphorus deficiency have been observed on the well-nodulated but poorly grown plants, despite the application of up to 4 cwt per acre of superphosphate. In these instances, good growth with no phosphorus deficiency symptoms is obtained where ground limestone at 1 ton per acre is applied in addition to the superphosphate. On two of these soils, namely Nala Sand on Flinders Island and Woolnorth Sand near Smithton, good growth has also been recorded in the absence of heavy lime where a less soluble phosphatic fertiliser (Rhenania phosphate) has been used. Recent work using radioactive superphosphate has shown that the phosphorus in superphosphate leaches rapidly from Nala Sand and that heavy dressings of lime retain considerable amounts of the applied phosphorus in the surface soil (Paton and Loneragan, in press). The immobilisation of phosphorus by lime may also be important on

other acid sandy soils where unexplained pasture responses to heavy dressings of lime have been recorded.

Lime Without Effect or Replaceable by Seed Inoculation

Poor nodulation is also experienced on several of the less acid soils (pH more than 5.2) of the state. In these cases, sowings made with uninoculated seed generally improve with time until a satisfactory clover pasture is obtained in two to three years. Dressings of lime at 1 ton per acre improve nodulation on some areas but have little effect on others. It appears that in the first instance, lime stimulates the growth of naturally occurring effective *Rhizobia* in the soil, but in the second, insufficient native *Rhizobia* are present for the lime to have an immediate effect.

Where soil conditions are favourable for the growth of *Rhizobia* but the number of organisms is low, problems of poor nodulation can generally be overcome by the use of suitable inoculation techniques. This implies that the *Rhizobia* must reach the soil in a viable condition and in sufficient numbers and that the soil environment is favourable for their survival. The main requirements are to use an effective culture of *Rhizobium*; to keep the inoculated seed out of contact with acid superphosphate and to sow, if possible, into a moist seed bed.

On many of these areas sowing inoculated seed through a small-seeds box attachment, so that the seed is kept separate from acid superphosphate, is all that is required. Where a separate seeds box is not available drilling the seed with light rates of ground lime or with a lime-superphosphate mixture as described earlier has also given good results.

It is on these less acid areas that lime coated seed appears to have a place. On several of these soils, inoculated, lime coated seed, drilled with acid superphosphate, has given good establishment provided inoculation is carried out *before* lime coating and within a day or two of sowing. Inoculated, commercial, lime coated seed—which must be inoculated *after* lime coating—has, when drilled with acid superphosphate, given little improvement in nodulation and growth in any Tasmanian trial to date.

Lime dusting of inoculated seed has given good results in both experimental and large scale sowings on several slightly acid soils. In this case, a sticking agent—e.g. gum arabic—is used in the inoculant and the wet inoculated seed is dried off immediately by dusting with fine calcium carbonate. The method is easily used by farmers and has given superior results to dry inoculation of commercial lime coated seed in all cases where the seed is mixed with acid superphosphate during sowing. The method is similar to that used successfully for sowing inoculated seed in Western Australia (Cass Smith and Goss 1959).

Although suitable seed inoculation techniques—e.g. sowing inoculated seed out of contact with acid superphosphate and the use of inoculated lime dusted seed—have overcome the problem of slow legume establishment on practically all soils of pH 5.5 or above investigated, less information is available regarding the effectiveness of these methods on the somewhat more acid soils (pH 5.2 to 5.4).

Certainly, on many of these areas, responses to seed inoculation are obtained when seed is drilled with lime or lime-superphosphate mixtures. However, significant improvements in both nodulation and growth frequently occur when uninoculated seed is sown in this way. It is not known whether the effects of lime in these cases is due simply to increased numbers of native *Rhizobia*, or whether some other effect is involved. The steady improvement made when uninoculated seed is sown without lime on many of these areas and also the good establishment recorded on some soils with pH's below 5.2 where very heavy doses of inoculum have been used in the absence of lime, suggests that the main effect of these small amounts of lime, at least on some Tasmanian soils, is on *Rhizobium* numbers. On the other hand, on leached sands in South Australia, the better growth obtained when seed is drilled with a 1:1 lime-superphosphate mixture is attributed to effects on germination and on calcium supply rather than on *Rhizobium* numbers (Smith, unpublished data).

Reduced germination of both grass and legume species have also been recorded on acid sandy soils in Tasmania when seed is

drilled with superphosphate at rates of 3 cwt or more per acre. Until the effects of these small amounts of lime have been better defined, it is recommended that lime or lime-superphosphate mixtures should be used for drilling pasture seeds on the moderately acid, light textured soils, particularly under dry conditions.

Establishment Problems Due to Nutritional Deficiencies

With suitable inoculation and sowing techniques, satisfactory nodulation of the sown clovers can now be obtained on most Tasmanian soils. However, although effectively nodulated, clover plants will not establish satisfactorily if growth is restricted by a deficiency of one or more of the essential plant nutrients. Furthermore, a deficiency of any nutrient not only restricts growth, but in the case of legumes, seriously limits the amount of nitrogen fixed by the plant-*Rhizobium* association.

The main soil deficiencies which affect the establishment and growth of pasture legumes in Tasmania are phosphorus, potassium, molybdenum and copper. Deficiencies of the remaining trace elements zinc, manganese, boron and iron have been recorded in isolated instances only.

Phosphorus

In their virgin state Tasmanian soils are severely deficient in available phosphorus and little growth can be expected in the absence of additional phosphorus. This is well recognised and superphosphate is always used in the establishment of improved pasture species. Not so well appreciated however, is that many of the soils now being developed are grossly deficient in phosphorus and that considerably higher rates of superphosphate are required for rapid and satisfactory establishment on these areas. Initial dressing of superphosphate at 3 cwt per acre followed by annual dressings of 2 cwt per acre for at least four or five years appear to be near the optimum amounts on many new areas.

Potassium

Potassium deficiency has been shown to be widespread in Tasmanian pastures (Paton 1956b). Although the deficiency most commonly occurs in the older agricultural areas

which have a history of heavy cropping, it is also sufficiently severe on some virgin areas to prevent satisfactory legume development. Potassium responses on new areas have been recorded only on light sandy soils.

The typical signs of potassium deficiency such as the rapid falling off in clover production, better growth of clover in urine patches and the characteristic leaf symptoms exhibited by clover species are now well recognised.

Applications of 1 cwt per acre of potash fertiliser appear to be near the most economic initial dressing on most soils. Work is in progress to determine the maintenance dressings of potash fertiliser required on various soil types and under different systems of management.

Molybdenum

Fricke (1944; 1945a; 1945b) showed that molybdenum deficiency in pastures was widespread in the North Midlands, North Eastern and North Western districts of the state. Since then pasture responses to molybdenum have been obtained in most of the developed areas of the state (Paton 1956a).

As a result of this work, large areas of the state have now been treated with molybdate superphosphate. However, new areas and soils not previously recognised as being molybdenum deficient are still being found. It is recommended that molybdenum should be tried on any area where adequate superphosphate has been applied but growth is poorer than expected.

Molybdenum deficiency in pastures is corrected by applying 2 cwt per acre of molybdate superphosphate—containing approximately 1½ oz of molybdenum. This dressing should not be repeated more than once every five years.

In trials on well established clover pastures, equivalent responses to molybdenum have been recorded in all instances where responses to heavy dressings (1 ton per acre) of lime have been obtained. This work has been carried out on a wide range of Tasmanian soils. Although it is not claimed that molybdenum will replace lime on all established pasture areas, it is apparent that the main effect of lime on

many Tasmanian soils is to increase the supply of molybdenum available to pasture plants.

Copper

Responses in pasture growth to copper have been recorded on many areas adjacent to the coast and particularly on the Bass Strait Islands (Paton 1956a).

Dressings of copper sulphate at 7 lb per acre have been adequate for maximum pasture production and in some instances the effect of these dressings have persisted for at least ten years. It appears however, that the copper requirements for stock health are higher than those for satisfactory pasture production. For this reason, recommendations regarding the maintenance dressings of copper should be in accordance with the animals requirements.

Multiple Deficiencies

With the information now available, good clover pastures can be established on practically all Tasmanian soils. However, on some soils now being developed and also on many of those remaining to be developed, deficiencies of several plant nutrients in addition to nodulation problems occur.

The importance of knowing the precise requirements for satisfactory nodulation and growth before any large scale development of these areas is attempted, is stressed. The omission of any one of the necessary treatments will result in poor establishment or even complete failure of the sown species. This is well illustrated in the case of the deep sands of the north east coast and also the strongly acid heathland soils in the far north west of the state where seed inoculation, lime, heavy superphosphate, copper and potash are all required for satisfactory pasture establishment and growth.

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Book Review

Grass Productivity

By Andre Voisin, translated by Catherine T. M. Herriot

Crosby Lockwood: London, 1959.

Few of the standard texts on grassland devote much space to grazing management. The appearance of an English translation of M. Voisin's book which brings together much of the work on both the plant and animal sides of the topic is therefore welcomed.

The book is concerned mainly with the deduction, enunciation, and practical application of four universal laws of rational grazing. Rational grazing is the author's term for a form of rotational grazing in which particular emphasis is placed on the use of rest periods that vary in length according to the rate of pasture regrowth. There are twelve parts in the book. The first is a discussion and illustration of the principles of pasture growth including the effect of nitrogenous fertilizers. Surprisingly, no mention is made of light as a factor in pasture growth. Dairy cattle are the only stock considered and in Part II their intake and utilization of herbage is dealt with. The remaining sections are much shorter and cover, with some repetition, the principles and practice of rotational grazing, errors in other management systems, special systems of rational grazing, the alteration of the pasture flora by grazing and practical matters such as subdivision and watering. In a section on the calculation of productivity M. Voisin gives an

example from his own farm that will commend his management to many (460 gallons of milk plus 550 lb live-weight gain per acre in one April-October season). It is to be hoped that means will be devised before long whereby a system such as this can be compared objectively with uncontrolled grazing under experimental conditions.

The inclusion of many quotations and tables from European literature that is not readily accessible, is a useful feature of the book.

The author makes a number of unqualified assertions that will disturb an informed reader as may his tendency to argue from the particular case to the general. There are a number of typographical errors at least two of which are carried over from the French edition.

The book is well printed, laid out in a manner that is easy to read and is illustrated with about 40 photographs.

Although to judge by the style adopted, the book is intended primarily for dairy farmers, everyone who is concerned with "the meeting of grass and animal" will find it worth reading whether or not they agree with the author.

J. L. WHEELER.

THE RELATIVE IMPORTANCE OF LEGUME SPECIES IN IMPROVED PASTURES

G. J. MARTIN

It is of interest to note that although there has been a widespread increase in the use of pasture legumes in Tasmania in the last 30 years there has not been any new contribution to the list of recommended clover species for improved pasture during that period. White clover, red clover, strawberry clover, crimson clover and alsike were being sown at the beginning of this century and subterranean clover was first reported in 1916. There have been considerable changes however, in the usage of these species. Before 1930 the short lived white Dutch strain of white clover was predominant and red clover (cow grass) and crimson clover were also commonly sown, improved pasture then being mainly confined to temporary leys in the higher rainfall districts. By 1930 the value of subterranean clover and perennial wild white clover was gaining recognition. However, while white clover remained confined to the more fertile, higher rainfall areas, subterranean clover, because of its greater adaptability, rapidly became the most highly regarded and widely used legume in both temporary and permanent pastures. Since the war the increased use of superphosphate is considered to have resulted in the wider use of perennial white clover and it has now gained prominence in all but the driest districts while crimson and alsike clovers have practically gone out of use.

From an agricultural viewpoint a species may include a diversity of plant types ranging from very poor to very good. Hence its full potential may be realised only if the best strains of that species are employed. Tasmania is fortunate in that in addition to suitable intro-

duced clover species being readily found, improved strains of these species developed in other countries have also proved to be of great value here. There are no native clovers in Tasmania nor have any natural strains of introduced species been isolated and developed as yet.

The Department of Agriculture established the value of New Zealand certified white clover and Mt. Barker subterranean clover strains some 25 years ago and it was quick to recommend their use. By the introduction of seed certification and the encouragement of the exclusive use of certified seed, both local and imported, the identity and high standards of these strains have been maintained and, by adopting a pasture farming practice commensurate with our present knowledge, the farmer is at last able to exploit their full potential.

In order to assess the relative values and characteristics of the clover species listed above each species is dealt with separately in order of its agricultural importance.

White Clover

White clover (*Trifolium repens*) should be regarded as the basic legume for improved pasture in areas where the average annual rainfall exceeds 22 inches. Formerly regarded as suitable only for moist, fertile soils, white clover has now shown itself adaptable to a

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wide range of soil and climatic conditions. Contrary to earlier opinion it has now been shown that, providing adequate quantities of superphosphate are used, white clover is easier to establish on marginal soils than subterranean clover. It is more tolerant of acid conditions and also apparently better adapted to utilise the naturally occurring strains of rhizobia in the soil (Paton 1957).

The New Zealand certified white clover strain is now sown almost exclusively either as imported seed or as locally produced seed of New Zealand origin, and it is undoubtedly the best general purpose strain available. As this strain has all the desirable qualities of white clover and is so well known it will be used as the basis for describing the general characteristics of the species.

New Zealand certified white clover is a vigorous, leafy, perennial with a prostrate, creeping, habit. It is very palatable and able to withstand hard grazing. Annual production is high relative to other clovers but unfortunately, without irrigation, it is often rather too confined to the spring, particularly in the northern, midland, and southern, pastoral regions when low summer rainfall and low winter temperatures are experienced. Whereas in districts of the north west and north east the spring flush is normally supplemented by reasonable growth in the early summer, autumn and early spring, in the former areas a dry summer and autumn may delay recovery until the following spring. This has been noted particularly where pastures have been subjected to heavy grazing pressure during the dry period which, of course, is usually inevitable.

The possibility of increasing the off seasonal growth of white clover by the use of alternative or supplementary strains is under investigation by the Department of Agriculture. One approach to this problem has been to assess the value of local lines which have been subjected to the Tasmanian environment over a long period in the hope that superior natural strains may have evolved which are better adapted for local conditions. Forty five samples from old white clover pastures have now been compared with the New Zealand certified strain as single

plants and in pure swards, but only four of these have equalled the control in general quality and annual productivity and no increase in off season production has been apparent.

The other approach has been to examine the potential of introduced strains for this purpose. Sixty introduced strains, mainly from countries with a Mediterranean climate, have been examined with more encouraging results. Several Mediterranean strains have demonstrated an appreciable increase in growth, compared with the New Zealand strain, during the autumn, early winter and early spring and three of these have been selected for further investigation. Tests so far have been confined to single plants and pure swards so it has yet to be determined whether this improvement would be realised in a normal pasture mixture. Furthermore, as these strains are less leafy and lower in total annual production than the New Zealand strain it is unlikely that they would be used other than in a supplementary role or as a source of breeding material.

Other strains of white clover that have been or are being used in Tasmania are Kentish wild white, Ladino, Victorian Irrigation white and white Dutch. Kentish wild white clover is a dense, small leaved strain, able to withstand hard grazing but it lacks the vigor of the New Zealand strain. Ladino clover is a giant form of white clover which, although quite vigorous, is open and stemmy and unable to withstand continuous grazing and vigorous grass competition. Victorian Irrigation white clover is somewhat intermediate between Ladino and New Zealand white clover in performance and type and is inferior to the latter even under irrigation.

White Dutch clover, is a short lived, relatively stemmy, low producing strain which was once predominant in volunteer and permanent pastures in the high rainfall districts. By basing white clover seed certification on the picric acid test it has been possible to virtually eliminate it as a contaminant in perennial white clover seed.

Subterranean Clover

As well as being the outstanding annual pasture legume subterranean clover (*Trifolium subterraneum*) is also of major importance in

improved permanent pasture particularly in areas receiving an annual rainfall of less than 30 inches. Its efficient seeding habit and seedling vigour enables it to propagate itself year after year in permanent pasture while the annual habit and hard seeds safeguard the species through summer drought.

The ability of subterranean clover to grow on poorer soils and in drier areas than white clover was quickly recognised. Steele (1930) reported on its value in the lower rainfall areas on medium and poor soils and Hudson (1932) described it as unsurpassed for worn out and over-cropped soils. These qualities coupled with high productivity, ability to establish by surface sowing and a steadily increasing use of superphosphate led to the spread of subterranean clover over a wide area between 1930 and 1950, subsequently enabling large tracts of native grasses to be replaced by improved grass species. This phase has been of major importance in the development of the northern, midland and southern pastoral areas.

Although white clover has now reduced subterranean clover to the role of a supplementary species in many areas, its importance must not be underestimated. It is better adapted and more reliable than white clover under dry conditions and it will continue to be the basic legume in the 18-22 inch rainfall areas. In the 23-30 inch rainfall regions it should be regarded as an essential supplement because of its superior growth during the autumn and early spring.

A further factor in favour of subterranean clover in dry areas is that the seed is a valuable source of protein and carbohydrates for sheep where they have to be carried on dry pasture through the summer. It is also desirable to have subterranean clover in the high rainfall areas as an off-season supplement to white clover but it is difficult to maintain a balance after the first year as white clover tends to become completely dominant.

Many strains of subterranean clover, all of mainland origin, have been tried in Tasmania, namely Mt. Barker, Bass, Bacchus Marsh, Wenigup, Tallarook, Clare, Yarloop and Dwalganup. The Mt. Barker Strain has proved the most suitable and it is now sown almost exclusively. Mt. Barker is a mid-season strain which

is moderately leafy, vigorous and adaptable to a wide range of conditions. Tallarook is a late, leafy strain which would be expected to do well in the cooler hill country, however, there is no evidence to indicate that it is preferred to Mt. Barker for this purpose in Tasmania. Yarloop is an early, stemmy strain which is particularly adapted for wet soil conditions but unless conditions are sufficiently mild to favor autumn and spring growth its performance is unimpressive.

The incidence of clover stunt virus has caused concern in recent years. This disease seriously reduces the autumn and early spring production of newly sown or volunteer stands in the first year after cultivation. Grylls and Butler (1958) have shown that whereas Mt. Barker is highly susceptible, Tallarook has a marked degree of resistance. This could have a favourable influence on the future use of the Tallarook strain.

Red Clover

Red clover (*Trifolium pratense*) is a short lived perennial best suited for one to three year leys but because the annual growth cycle of this species is more evenly distributed than the two main clovers it is also a valuable supplement in the early life of permanent pasture in the higher rainfall areas and it is now being used extensively for this purpose. The inherent ability of red clover to grow throughout the spring, summer and autumn makes it a valuable species for irrigation mixtures or for sowing in association with cocksfoot in special purpose pastures.

There are two strains of red clover in general use. Broad red clover, better known as cow grass, a vigorous biennial, and Montgomery red clover, a slower growing perennial strain. Cow grass is an erect, early, high producing strain which has always been held in high regard in temporary pasture for hay and for early summer, autumn, and early spring, grazing. Its vigorous erect habit enables it to compete successfully with other improved species such as the ryegrasses, subterranean clover and white clover so that it is of considerable value in supplementing permanent pasture mixtures in the first two years.

Montgomery red clover is a relatively recent introduction. It is a more perennial, leafy

strain which is better adapted for close grazing and is therefore regarded as being more suitable for permanent pasture than cowgrass. However, it is late, slow to establish, and generally less vigorous and consequently it tends to be seriously suppressed by other permanent pasture species particularly in the first year. This competitive pressure appears to have a serious effect on plant survival and there is some doubt as to whether the perennial habit has any practical significance under Tasmanian conditions.

Strawberry Clover

The sowing of strawberry clover (*Trifolium fragiferum*) has always tended to be restricted rather than general. It is a perennial clover, somewhat similar to white clover in appearance but more stemmy and less productive. Its main value is in its relative tolerance of waterlogged, saline, or drought conditions. For this reason it is recommended for sowing on areas which are too wet for white clover but not permanently water logged. It is also useful on highly alkaline soils and in the reclamation of areas where pasture growth is beginning to decline through the accumulation of salt. There are many minor depressions throughout the midlands which are waterlogged in the winter and dry out in the summer where strawberry clover could be used to advantage. Under normal conditions strawberry clover is unable to compete with white clover or perennial ryegrass but in wet places it rapidly becomes dominant and provides valuable grazing on what might otherwise be waste land.

Palestine strawberry is the most suitable strain available. It was first produced commercially in South Australia in 1938. It is a relatively vigorous, rather erect, large leaved strain which is noted for its winter growth. This feature, however, is only apparent in mild coastal districts. O'Connors strawberry clover is another South Australian strain on the market. This strain is more prostrate, dense and resistant to grazing but much less productive.

Crimson Clover

Crimson clover (*Trifolium incarnatum*) was particularly popular in the north east before the war. Hicks (1930) described it as a valuable annual which grows to perfection in the Scottsdale district. It was also grown in the north and north west to a lesser extent. It is an erect, stemmy, hairy annual suitable for one grazing followed by a hay crop. Before the war it was considered to be an ideal companion species for oats which were commonly subjected to one grazing and then cut for hay.

The imported commercial strains are typical of the description given above and their use cannot be recommended when cowgrass will provide greater over-all production, has greater longevity and will produce better quality hay. The persistent use of crimson clover in the north east appears to have resulted in the development of a local natural strain which is more leafy, less erect and later to mature than the commercial strains. It appears to be better adapted for grazing and its value relative to introduced and other local lines is at present under investigation.

Alsike Clover

Alsike clover (*Trifolium hybridum*) has never been regarded as an important pasture legume and is now rarely sown. It requires moist, fertile soils for optimum growth and persistence and its effective period of production is very much confined to the spring. However, because alsike clover is tolerant of wet and slightly saline conditions it could be useful as a supplement to strawberry clover in the reclamation of poorly drained areas and tidal flats.

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DISORDERS OF ANIMALS CAUSED BY LEGUMES

S. BENNETT

If we consider the modern improved pasture in relation to the animals that eat it then it is not surprising that legumes do, on occasions, produce ill effects in the animals. The animals that our live-stock industry depends on are mostly ruminants which are equipped with a set of four stomachs designed to handle roughage, whereas much of the pasture that they graze on could be more adequately described as a protein-rich concentrate.

Bloat

In Tasmania probably the greatest "killing" disease of cattle—and one which occurs almost exclusively on leguminous pasture—is bloat. This disease, which is mostly a disease of dairy cattle, costs the state somewhere in the vicinity of £175,000 per annum. This sum is all the more staggering when it is remembered that bloat is a strictly seasonal disease, being confined to not much more than three months of the year. The exact loss from bloat is not easy to assess. Many surveys have been made in various parts of the world from time to time, and these have been summarised by Johns (1956).

In Wisconsin, U.S.A. for instance, a survey of 8,000 farms suggested that 30,000 cows develop bloat in that State each year, and of that number nearly 6,000 die, representing an annual loss of over two million dollars in Wisconsin alone. The estimated annual loss from bloat in the United States of America is approximately forty million dollars.

A New Zealand survey carried out by the New Zealand Dairy Board in the 1953-54 season showed that more than one cow in 200 died from bloat in that season in New Zealand, representing a loss of 10,000 cows. In the

season 1954-55 the loss in New Zealand was estimated at 15,000 cows (Johns *et al.* 1957).

A rather restricted survey conducted in 1951 in the Kentish Municipality on the north-west coast of Tasmania by Bennett and Halpern (1952) revealed that on the 72 properties that supplied information 304 cases of bloat occurred in 1,790 head of cattle. Of the 304 cases, fifty died. From information received from the proprietor of a local fertiliser works and from stockowners themselves, it is estimated that in September 1959 at least 80-90 head of stock died from bloat in the Latrobe, Devonport and Kentish municipalities. Since October is usually the worst month for bloat in this area, and considerable losses continue into November, it is the opinion of the author that not less than 200 head of cattle died from bloat in these three municipalities in the last year. Taking these districts as a guide, it is believed that in the whole of the state the annual mortality is something like 2,000 head.

The loss from bloat is far greater than is indicated by the number of dead cows. In animals which recover there is a considerable loss of milk production. Some develop peritonitis following the use of the trochar or crude surgery in an effort to relieve the acutely bloated animal. Many owners report that in periods when bloat is occurring all cows are extremely restless and don't milk as well even if not actually bloated.

During an outbreak, the normal farm routine is greatly upset. A farmer is not able to carry out his other duties and sometimes he uses up reserves of hay and silage in an attempt to prevent bloat occurring.

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There is general agreement that, although bloat has been reported on numerous types of feed, legumes are the principle cause. Lucerne, white clover, red clover, subterranean clover and even peas have been incriminated. There does not seem to have been much recorded work done on the bloating potential of various strains of clover. Generally speaking, the more recently bred strains of clover are more vigorous and therefore more likely to produce a clover dominant pasture, hence the need for careful pasture management.

There is no information yet on the changes which convert a harmless pasture to a dangerous pasture, nor can any test, other than actual grazing, be applied to decide whether it is safe. It has been claimed that fertiliser treatments, soil deficiencies, etc. have an influence on the bloating of pasture, but no proof has been provided. Likewise, many opinions have been expressed as to the effect of climate and weather on the incidence of bloat, but there doesn't seem to be any consistency in the opinions on these matters.

Recent research work has shown that bloat is due to foam formation in the rumen; the normal mechanisms of eructation and regurgitation cannot cope with foam, which therefore accumulates. Some free gas also exists in the rumen.

In acute cases the foam is very stable, highly viscous and can block a stomach tube, trochar, or even a surgical incision. The reason for the great stability of the foam is uncertain, but it is believed that saponins and proteins in the plant leaves, the animals own saliva, and products of bacterial activity are all involved. In the rumen there exists a normal anti-foaming mechanism, but in bloat this mechanism may be interfered with.

Several preventive measures have been evolved to minimise the losses from bloat. They include—

Pasture Control. As it seems we cannot dispense with clovers, the aim must be to prevent pastures becoming clover dominant.

Grazing Control. One of the widely adopted methods of controlling the grazing of animals is to enforce strip or break grazing by means of the electric fence. It is of considerable value in

the good utilisation of pasture and it is responsible for some control over bloat, but labour costs in this system of grazing are high.

Feeding Roughage. Feeding hay before turning cattle onto bloaty pasture is not always reliable according to Johns (1956). The use of silage as a pre-feed in bloat control does not appear to have been tested under critical conditions.

Use of Anti-foaming Agents. The use of anti-foaming agents has been put forward as the answer in bloat prevention. However the intake of anti-foaming agents must be continuous. A single dose of an anti-foaming mixture protects against bloat for one feed only and then appears to be rapidly lost from the rumen.

Since any oil used for bloat prevention may have to be used over a long period of weeks, it is important that the substance be non-toxic, cheap, and have no effect on milk flavour. In addition it must not depress the milk yield.

Some oils had to be discarded because of their laxative effect or effect on absorption of vitamins from the bowel. The most suitable substances were found to be peanut oil and tallow. Cream is also effective. Emulsified peanut oil at the rate of 2 oz-4 oz per head per day gave complete control of bloat in trials conducted in New Zealand. Administration of anti-foaming agents in the drinking water has been tried, but since the water intake varies the method has serious limitations.

In Tasmania peanut oil is rather expensive and it is likely that tallow will be used where spraying of pasture is adopted. Special emulsifying agents are required and detailed instructions must be followed fairly closely to get the tallow into a suitable material for use in a boom spray.

Feeding of Antibiotics. The administration of antibiotics in the food has been successfully used to reduce fermentation in the rumen. Penicillin has proved to be the only antibiotic without undesirable side-effects. However, it is not taken very well in the ration by some animals, but can be given in tablet form.

After penicillin has been given every two days for some twelve doses, the beneficial effect of penicillin as a bloat preventative tends to disappear.

Clover Disease

The second legume disease worthy of note is the so-called clover disease.

From about 1940 onwards serious breeding disorders, abnormalities of the sex organs, and infertility in ewes, became apparent in areas of Western Australia where pastures were predominantly subterranean clover.

Subterranean clover had been of great importance in increasing the productivity of large areas in the West.

Clover disease, as it was called, was believed at first to be restricted to Western Australia but was later recognised in other parts of Australia in association with subterranean clover-dominant pastures and has been recorded in Tasmania.

The disease is caused by the consumption of excessive amounts of subterranean clover which has been shown to contain the oestrogen genestein. Exposure to the action of this sex hormone for long periods results in gross abnormalities of the sexual organs. The changes caused by prolonged grazing on this clover have been reproduced in sheep and laboratory animals by feeding stilboestrol, a known oestrogen.

It has been shown that subterranean clover is dangerous from germination to wilting time. After wilting time there is a rapid loss of toxicity. It appears that any known strain of subterranean clover could cause trouble since Curnow and Rossiter (1955) reported that over 120 strains were found to contain appreciable concentrations of the oestrogen genestein.

Dr. Bennetts, in Western Australia, reports that in ewes the effects of clover grazing are progressive and cumulative. One season's grazing of green clover may induce signs of the disease, but the number of ewes affected increases progressively with the years.

There are a variety of manifestations of clover disease.

Dead Lambs. Some affected ewes give birth to dead or weak lambs which are however carried to full term. Dystocia is common. A weak attempt at lambing, often in the standing position, may result in the loss of foetal fluids, but no further progress is made. Such ewes

may not be detected for some days, by which time putrefactive changes in the dead foetus have advanced to the stage where the life of the ewe is in danger. The mortality in such cases can be high.

Infertility. While clover disease may appear in the first year in the form of many dystocias, in subsequent years infertility is the most notable feature.

There is an increasing number of empty ewes each year until within four to five years the lambing percentage may fall to below 10 per cent. Investigations have shown that ewes fail to conceive because of the cystic condition which develops in the uterus after animals are kept for prolonged periods on potent clover. The cystic condition is irreversible and ewes remain permanently sterile.

Prolapse of Breeding Organs. Prolapse of the uterus is common in clover disease, and deaths are likely from infection and toxæmia. Attempts to replace the prolapse are not very successful.

High Tail. The action of the clover oestrogen on the ligaments of the pelvis and sacrum results in a condition, described as high tail, which does not always appear to affect the health of the ewe but is indicative of excessive intake of subterranean clover.

Effect on Wethers. The effect of clover oestrogen on wethers is twofold; it induces lactation and produces a condition referred to as false bladder. In some wethers there is a marked development of the teats with some milk production. In the condition referred to as false bladder a fluctuating swelling develops below the anus in the bulbourethral glands. It can prove fatal in a small percentage of an affected flock. Rams are not affected.

The control for clover disease is to prevent ewes from regularly eating excessive amounts of green subterranean clover of any strain.

The theory that fertiliser treatments may influence the oestrogenic potency of subterranean clover was investigated and reported by Alexander and Rossiter (1952).

They found that the oestrogenic potency of subterranean clover from plots which received superphosphate, together with several other

fertilisers did not differ significantly from that of clover from a plot getting superphosphate only. On the other hand clover from plots receiving no fertiliser recently was significantly more potent than clover from plots which had received superphosphate.

It would appear that subterranean clover is not the only pasture legume to contain oestrogens, although no others have been demonstrated to produce abnormalities in stock.

Lucerne for instance has been shown to contain oestrogens and the level varies throughout the season.

Significant oestrogenic activity has been demonstrated in Ladino clover, red clover and birdsfoot trefoil (Pieterse and Andrews 1956).

Sheathrot

The disease sheathrot or non-contagious posthitis of sheep is another disease which is fairly common in Tasmania and one which occurs on improved pastures. There are still some gaps in our knowledge of sheathrot, but it has often been associated with a high protein diet. Cases have been produced experimentally by feeding a leguminous diet.

Beveridge and Johnstone (1953) reported that sheathrot is less prevalent in poor seasons and most prevalent in years where there is much leguminous herbage. It is practically unknown on the non-leguminous native pastures of New England in New South Wales. In Tasmania improved pastures have been apparently responsible in most outbreaks. Experience has shown that the disease clears up when the affected wethers are moved onto poorer feed. On the mainland it has been demonstrated that the disease can be cleared up by moving affected sheep onto capeweed dominant pasture or onto a diet of oaten chaff.

A similar disease in ewes, called ulcerative vulvitis, has been seen in Tasmania in young ewes running on red clover. This disease is characterised by ulceration of the vulva and sometimes death from secondary infection which spreads up the urinary tract to the kidney causing a fatal purulent pyelonephritis.

Photosensitisation

Photosensitisation, facial dermatitis, trefoil dermatitis, or sunburn, are names given to a

condition of stock where the exposed unpigmented skin reacts to light, particularly direct sunlight and becomes burned or scalded. The disease is particularly prone to occur on improved pastures. In New South Wales in good years when there is an abundant growth of trefoil (*Medicago* spp.) it is frequently seen in sheep.

Cattle and horses can be affected as well, and from September to December cases of photosensitisation are commonly encountered in cattle in Tasmania. Hereford cattle seem particularly susceptible and the whole of the white face, muzzle, eyelid, and other unpigmented parts of the body become oedematous, the skin later becoming leathery, and if the animal survives, as it mostly does, the skin on the areas affected peels right off. It has been shown that the chlorophyll of plants is broken down in the rumen to form a fluorescent body called phylloerythrin which is normally excreted in the bile. When for some reason there is a slowing down of this excretion in the bile, as happens in this disease, this phylloerythrin circulates throughout the body and has the effect of sensitising the unpigmented skin to the harmful effects of ultra-violet light.

Various plants have been found to predispose to this disease, including a large number of legumes, such as white clover, subterranean clover, burr clover (*Medicago lispida*), alsike clover (*T. hybridum*), lupins, vetches, trefoils (*Medicago* spp.).

Enterotoxaemia

Although not directly due to legumes, enterotoxaemia of lambs and sheep must be considered in this review, because legumes seem to play such a very important part in predisposing to this disease.

Enterotoxaemia or pulpy kidney is a disease which is generally regarded as being due to a particular toxin produced within the gut by the bacteria *clostridium welchii*, type D. However feed conditions play an important part in making the environment within the bowel suitable for the development of the pulpy kidney germ. High protein feed, particularly legumes, have long been regarded as most likely to provide these conditions. Sheep running on clover-dominant pasture, particularly sub.

clover, are most susceptible. It has also been noticed that even when clover dominant pastures have dried off and sheep are grazing to a large extent on clover seed heads, enterotoxaemia is likely to occur.

Muscular dystrophy

A disease of lambs reported by Hartley and Dodd (1957) in New Zealand, and which may occur here, is muscular dystrophy, white muscle disease, or stiff lamb disease. In New Zealand it occurs in late winter and spring in lambs up to three months of age, but usually from three to six weeks of age.

It is seen in flocks where ewes in the late stages of pregnancy and early lactation have been break-fed on autumn-saved, legume-dominant pasture, supplemented by excellent quality lucerne hay, and also where ewes have been wintered on swedes or turnips and moved at lambing on to lush legume dominant pasture. The legumes involved are mostly red and white clovers, but lucerne and subterranean clover have also been incriminated.

Lambs with white muscle disease have a stiff stilted gait and are not keen to move. If the muscle of the heart is affected sudden deaths can occur. Post-mortems on affected cases reveal pale coloured sections of muscle usually in the thigh.

It was previously believed that white muscle disease was due to a vitamin E deficiency, but there seems to be some anti-vitamin E factor in leguminous pasture which produces the same effect.

Other Disorders

A small group of legumes has been reported at various times to cause deaths from prussic acid or cyanide poisoning. These particular legumes have been shown to contain a cyanogenetic glycoside which is capable of being broken down in the rumen to prussic acid. Legumes in this group include birdsfoot trefoil (*Lotus Australia*) and vetches (*Vicia sativa*). Even white clover (*T. repens*) has been shown to contain this prussic acid producing substance, and in New Zealand a good many deaths of cattle from this cause have been reported. Certain strains of white clover may be more dangerous than others. It is likely that

deaths from this cause have occurred in stock in this state, but the number must be fairly low.

In the field of trace element work, clovers are of special significance. The uptake of some trace elements by legumes is higher than some other pasture species, and so on marginal country clovers have a special value in maintaining good animal health. However this characteristic of clovers can operate in reverse as is shown by figures quoted by Russell and Duncan (1956).

In Somerset in the United Kingdom where a scouring disease of cattle is very prevalent, the cause has been shown to be due to excessive molybdenum in the feed. Clovers were demonstrated to contain twice as much molybdenum as the grasses from the same pasture, so that the leguminous part of the diet was contributing more than its share towards the molybdenum poisoning.

Some legumes are reported to be unsuitable for the flushing of ewes (Barton 1955). Lucerne has been claimed to have an anti-flushing effect to the extent of reducing lambing percentages by as much as 17 per cent. Regrowth red clover which is growing rapidly from the crown is also regarded by some farmers as quite unsuitable for flushing purposes. Similarly subterranean clover, which is making rapid growth in the early autumn, is also believed to be unsuitable. With these reservations, however, flushing can be achieved on any food which rapidly raises the body weight of ewes.

In conclusion, mention should be made to a group of plants which while not of importance in Tasmania are nevertheless of some interest in any discussion on the toxicity of legumes, i.e. the sweet clovers (*Melilot altissimus* and *M. albus*). These clovers are found wild on British pastures and are of importance as forage crops in North America and Russia. Improperly cured or spoiled hay from these species does sometimes produce a rather deadly substance called dicoumarol which is toxic by virtue of the fact that it prevents clotting of the blood. Autopsies on animals which have died from sweet clover poisoning are characterised

by large haemorrhages in the subcutis and in the body cavities.

An interesting related species to the sweet clovers, the King Island Melilot (*M. indicus*) can cause tainting of the milk and has been reported to occasionally cause paralysis.

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ERRATUM

Volume 25, No. 4, Page 314.

The footnote to Table 1 (of the Technical Note "Growth rates of lucerne and *Glycine javanica* in a tropical highland environment") should read:—

*Sown at 4 lb/acre in March, 1958.

not, as printed

*Sown at 4 lb/acre in March, 1956.

ANOTHER LOOK AT AGRICULTURAL ENGINEERING

J. G. PORTERFIELD

In 1953 Vasey described in detail the, then, current concepts of agricultural engineering in several countries. These concepts have not altered appreciably since then. The principle changes taking place in agricultural engineering throughout the world in the past decade have been the increase in number of people trained in this field, and the increasing diversity of tasks undertaken. Agricultural engineers are today called on for help by more segments of the agricultural industry than ever before.

It may serve a useful purpose to review the meaning of agricultural engineering.

Agricultural engineering is the application of engineering knowledge to the problems of agricultural production, with the specific objective of achieving economically workable solutions, beneficial to the agricultural industry. The key words in this description are, to achieve a solution to problems of agricultural production by the application of engineering knowledge.* This seems to imply:

- Agricultural engineers are people who practise the art and science of professional engineering.
- Agricultural engineers concern themselves with agricultural problems which yield to the application of engineering knowledge.
- Agricultural engineers work on agricultural problems for the express purpose of finding satisfactory solutions to these problems.

*Engineering knowledge is usually conceded to encompass the generation, control and application of energy and the management of materials to satisfy a functional demand.

- Since applied engineering knowledge alone may not solve agricultural problems, the agricultural engineer generally joins other agricultural specialists in a combined attack on a specific problem.

This is a broad description, but one consistent with the present concepts of this profession.

In many countries, professional agricultural engineers have had formal training in colleges and universities, and possess engineering degrees in agricultural engineering. In the United States, for example, professional agricultural engineers have been trained in engineering fundamentals with additional study devoted to several specific areas of agricultural engineering.

These specific areas are:

- Farm power and machinery: design, testing and management.
- Farm buildings and their equipment.
- Soil and water engineering, including irrigation, drainage, soil erosion control, flood control and land clearing.
- Farm processing and special applications of electricity to agricultural production.

In other countries formal training may in-

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INDEX

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AUTHORS

Barrow, N. J. and Spencer, K.	
Lateral movement of fertilizer sulphur	208
Basinski, J. J. and Thomson, N. J.	
Bacterial blight of cotton in North Western Australia	297
Baxter, J. P.	
Atomic energy and agriculture for the future	34
Blake, C. D. and Conroy, R. J.	
Some nematodes as factors in yield reduction and spawn degeneration in the cultivated mushroom, <i>Agaricus hortensis</i> (Cke.) Imai	213
Bromfield, S. M.	
The microbial decomposition of sugar and its effect on phosphate solubility	67
Broué, P. and Strang, J.	
The effect of nitrogen on non irrigated maize sown in pasture slits	312
Brown, A. G.	
Mistletoe control on a large scale	282
Clunies Ross, I.	
The contribution of science to the future of agriculture	31
Conroy, R. J.	
Black ringspot disease of crucifers	64
Conroy, R. J.	
The commercial mushroom industry in N.S.W.	176
Conroy, R. J. and Blake, C. D.	
Some nematodes as factors in yield reduction and spawn degeneration in the cultivated mushroom, <i>Agaricus hortensis</i> (Cke.) Imai	213
Coombe, J. B.	
The effect of supplementation with urea and molasses on the liveweight, appetite and wool growth of sheep	299
Costin, A. B.	
Replaceable and irreplaceable resources and land use	3
Couchman, Jean S.	
Changes in the soluble sugar contents of short rotation ryegrass during growth	315

Crawford, J. G.	
Is an efficient agriculture all that is necessary for an effective trade policy	48
Crosbie Morrison, J. W.	
The gross protein value of Australian meat meals	63
Cuthbertson, E. G.	
Residual response to urea fertilization	295
Dolling, C. H. S.	
The Poll Dorset	259
Dolling, C. H. S.	
The Poll Merino	109
Edye, L. A. and Griffiths Davies, J.	
<i>Sorghum alnum</i> Parodi—a valuable summer-growing perennial grass	117
Freer, M. and Tribe, D. E.	
The effect of an autumn application of nitrogenous fertilizer to irrigated pastures on the production of grazing dairy cows	306
Giles, J. E. and Sauer, M. R.	
Nemagon and Vapam for the control of root knot of field tomatoes	138
Gooding, D.	
The use of <i>Botulinus</i> toxin as a poison for Kangaroo (Marloo) control in W.A.	141
Greenhill, W. L.	
The effect of crushing on the drying of pasture plants	58
Greenhill, W. L.	
The effect of laceration on the drying of pasture plants	61
Greenwood, R. H.	
Must people starve in the twentieth century	184
Griffiths Davies, J. and Edye, L. A.	
<i>Sorghum alnum</i> Parodi—a valuable summer-growing perennial grass	117

Grncarevic, M. and Martin, R. J. L. Fermentation of the cold dip used for drying sultanas 221	McMillan, R. B. Wool in the world market and in Aus- tralia's economy 189
Gunn, W. A. The producer's view of the next twenty- five years 41	Malcolm, C. V. An air-pycnometer for field use 223
Hill, A. V. Occurrence, spread and severity of blue mould, <i>Peronospora tabacina</i> Adam, of tobacco in field plants 55	Martin, R. J. L. and Grncarevic, M. Fermentation of the cold dip used for drying sultanas 221
Hingston, F. J. The loss of applied phosphorus and sul- phur from soils under pasture in W.A. 209	May, P. Inhibition of rooting by maleic hydra- zide 304
Humphrey, G. F. The future of Australian fisheries 45	Melville, J. Chemistry and the future of agriculture 37
Iismaa, O. Microdetermination of sulphur in plant material 136	Moore, R. M. The Institute—its role in the profession and in the agricultural community 171
Kyneur, G. W. Growth rates of lucerne (Hunter River) and <i>Glycine javanica</i> in a tropical high- land environment 314	Neal-Smith, C. A. and Walker, A. J. K. The history, characteristics and potential of Clare subterranean clover 18
Lang, W. R. and Wardle, B. R. Wool fibre thickness frequency distribu- tion in the staple: the proximal sample compared with the whole staple 294	Norris, D. O. Legume bacteriology in the tropics 202
Levi, E. The control of water couch, <i>Paspalum distichum</i> L, in irrigation channels by 3-Amino 1,2,4-triazole (Amizole) 62	Parker, M. L. Programming for farm management ex- tension 267
McEwen, J. Government policy and attitude to the future of Australian agriculture 251	Priestley, C. H. B. Heat conduction and temperature profiles in air and soil 94
McGarity, J. W. The influence of sod-seeded legumes on the nitrogen economy of grassland soils at Lismore, N.S.W. 287	Raupach, M. and Tucker, B. M. The field determination of soil reaction 129
	Roberts, F. J. The magnesium supplying power of glazed porcelain pots 298
	Sauer, M. R. and Giles, J. E. Nemagon and Vapam for the control of root knot of field tomatoes 138
	Schapper, H. P. Farm management clubs for Australia 23

Shepherd, W. Effects of a chemical dessicant on the speed of curing of hay 218	Tucker, B. M. and Raupach, M. The field determination of soil reaction 129
Shepherd, W. Weather damage to exposed hay bales 308	
Spencer, K. and Barrow, N. J. Lateral movement of fertilizer sulphur 208	
Strang, J. and Broue, P. The effect of nitrogen on non irrigated maize sown in pasture slits 312	Walker, A. J. K. and Neal-Smith, C. A. The history, characteristics and potential of Clare subterranean clover 18
Stubbs, L. L. Plant virology in Australia 11	Walker, M. H. Cool storage to reduce herbage dry matter losses after harvest 216
Swain, F. G. Effects of fertilizer and lime pelleted seed on nodulation and growth of vetch on the red basaltic soils of the Lismore region 134	Wardle, B. R. and Lang, W. R. Wool fibre thickness frequency distribu- tion in the staple: the proximal sample compared with the whole staple 294
Swain, F. G. Responses to molybdenum three years after previous application on red basaltic soils on the far north coast of N.S.W. 51	Wells, C. B. Useful correlations between results of fertilizer trials and other field data ... 273
Thomson, N. J. and Basinski, J. J. Bacterial blight of cotton in North West- ern Australia 297	Williams, D. B. Getting research results to woolgrowers 192
Tribe, D. E. and Freer, M. The effect of an autumn application of nitrogenous fertilizer to irrigated pastures on the production of grazing dairy cows 306	Yeates, N. T. M. Slide rule for judging and grading beef carcases 301

SUBJECTS

Agriculture

Atomic energy and agriculture for the future, by J. P. Baxter 34
Chemistry and the future of agriculture, by J. Melville 37
The contribution of science to the future of agriculture, by I. Clunies Ross 31
Is an efficient agriculture all that is neces- sary for an effective trade policy, by J. G. Crawford 48
Government policy and attitude to the future of Australian agriculture, by J. McEwen 251

The Institute—its role in the profession and in the agricultural community, by R. M. Moore 171
Must people starve in the twentieth cen- tury, by R. H. Greenwood 184
The producer's view of the next twenty- five years, by W. A. Gunn 41
Wool in the world market and in Austra- lia's economy, by R. B. McMillan 189
Animal nutrition
The effect of supplementation with urea and molasses on the liveweight, appetite and wool growth of sheep, by J. B. Coombe 299
The gross protein value of Australian meat meals, by J. W. Crosbie Morrison 63
Atomic energy
Atomic energy and agriculture for the future, by J. P. Baxter 34

Atmosphere		
Heat conduction and temperature profiles in air and soil, by C. H. B. Priestley	94	
Bacteria		
Bacterial blight of cotton in North Western Australia, by N. J. Thomson and J. J. Basinski	297	
Blue Mould		
Occurrence, spread and severity of blue mould, <i>Peronospora tabacina</i> Adam, of tobacco in field plants, by A. V. Hill	55	
Book reviews 33, 44, 47, 107, 116, 143, 247, 257, 266, 293,	319	
Cattle		
Slide rule for judging and grading beef carcasses, by N. T. M. Yeates	301	
Chemistry		
Chemistry and the future of agriculture, by J. Melville	37	
Conservation		
Replaceable and irreplaceable resources and land use, by A. B. Costin	3	
Cotton		
Bacterial blight of cotton in North Western Australia, by N. J. Thomson and J. J. Basinski	297	
Dairying		
The effect of an autumn application of nitrogenous fertilizer to irrigated pastures on the production of grazing dairy cows, by M. Freer and D. E. Tribe	306	
Ecology		
Replaceable and irreplaceable resources and land use, by A. B. Costin	3	
Equipment		
An air-pycnometer for field use, by C. V. Malcolm	223	
Slide rule for judging and grading beef carcasses, by N. T. M. Yeates	301	
Experimental techniques		
The history, characteristics and potential of Clare subterranean clover, by A. J. K. Walker and C. A. Neal-Smith	18	
The magnesium supplying power of glazed porcelain pots, by F. J. Roberts	298	
Extension		
Farm management clubs for Australia, by H. P. Schapper	23	
Getting research results to woolgrowers, by D. B. Williams	192	
Programming for farm management extension, by M. L. Parker	267	
Fertilizers		
The effect of an autumn application of nitrogenous fertilizer to irrigated pastures on the production of grazing dairy cows, by M. Freer and D. E. Tribe	306	
The effect of nitrogen on non irrigated maize sown in pasture slits, by P. Broue and J. Strang	312	
Effects of fertilizer and lime pelleted seed on nodulation and growth of vetch on the red basaltic soils of the Lismore region, by F. G. Swain	134	
Lateral movement of fertilizer sulphur, by N. J. Barrow and K. Spencer	208	
The loss of applied phosphorus and sulphur from soils under pasture in W.A., by F. J. Hingston	209	
The microbial decomposition of sugar and its effect on phosphate solubility, by S. M. Bromfield	67	
Residual response to urea fertilization, by E. G. Cuthbertson	295	
Responses to molybdenum three years after previous application on red basaltic soils on the far north coast of N.S.W., by F. G. Swain	51	
Useful correlations between results of fertilizer trials and other field data, by C. B. Wells	273	
Fisheries		
The future of Australian fisheries, by G. F. Humphrey	45	
Fodder conservation		
Changes in the soluble sugar contents of short rotation ryegrass during growth, by Jean S. Couchman	315	

The effect of crushing on the drying of pasture plants, by W. L. Greenhill	58
The effect of laceration on the drying of pasture plants, by W. L. Greenhill	61
Effects of a chemical dessicant on the speed of curing of hay, by W. Shepherd	218
Weather damage to exposed hay bales, by W. Shepherd	308
Fumigants	
Nemagon and Vapam for the control of root knot of field tomatoes, by M. R. Sauer and J. E. Giles	138
Fungi	
Occurrence, spread and severity of blue mould, <i>Peronospora tabacina</i> Adam, of tobacco in field plants, by A. V. Hill	55
Genetics	
The Poll Dorset, by C. H. S. Dolling	259
The Poll Merino, by C. H. S. Dolling	109
Growth inhibition	
Inhibition of rooting by maleic hydrazide, by P. May	304
The Institute	
The Institute—its role in the profession and in the agricultural community, by R. M. Moore	171
Institute Affairs	
The Australian Medal of Agricultural Science, 1959	160
Branch notes	88, 166, 241, 341
Federal President, 1959	159
List of members	345
R. J. Noble	122
Personal notes	85, 163, 239, 339
Irrigation	
The control of water couch, <i>Paspalum distichum</i> L., in irrigation channels by 3-Amino 1,2,4-triazole (Amizole), by E. Levi	62
Kangaroos	
The use of Botulinus toxin as a poison for Kangaroo (Marloo) control in in W.A., by D. Gooding	141

Land utilization	
Replaceable and irreplaceable resources and land use, by A. B. Costin	3
Legumes	
Effects of fertilizer and lime pelleted seed on nodulation and growth of vetch on the red basaltic soils of the Lismore region, by F. G. Swain	134
Growth rates of lucerne (Hunter River) and <i>Glycine javanica</i> in a tropical high-land environment, by G. W. Kyneur	314
The influence of sod-seeded legumes on the nitrogen economy of grassland soils at Lismore, N.S.W., by J. W. McGarity	287
Legume bacteriology in the tropics, by D. O. Norris	202
Letters	73, 227, 325
Magnesium	
The magnesium supplying power of glazed porcelain pots, by F. J. Roberts	298
Maize	
The effect of nitrogen on non irrigated maize sown in pasture slits, by J. Strang and P. Broue	312
Marketing	
Is an efficient agriculture all that is necessary for an effective trade policy, by J. G. Crawford	48
The producer's view of the next twenty-five years, by W. A. Gunn	41
Wool in the world market and in Australia's economy, by R. B. McMillan	189
Meat	
Slide rule for judging and grading beef carcasses, by N. T. M. Yeates	301
Microbiology	
Legume bacteriology in the tropics, by D. O. Norris	202
The microbial decomposition of sugar and its effect on phosphate solubility, by S. M. Bromfield	67
Mistletoe	
Mistletoe control on a large scale, by A. G. Brown	282
Molybdenum	
Responses to molybdenum three years after previous application on red basaltic soils on the far north coast of N.S.W., by F. G. Swain	51

Mushrooms

- The commercial mushroom industry in N.S.W., by R. J. Conroy 176
- Some nematodes as factors in yield reduction and spawn degeneration in the cultivated mushroom, *Agaricus hortensis* (Cke.) Imai, by C. D. Blake and R. J. Conroy 213

Nematodes

- Nemagon and Vapam for the control of root knot of field tomatoes, by M. R. Sauer and J. E. Giles 138
- Some nematodes as factors in yield reduction and spawn degeneration in the cultivated mushroom, *Agaricus hortensis* (Cke.) Imai, by C. D. Blake and R. J. Conroy 213

News items 79, 151, 235, 337

Nitrogen

- The effect of an autumn application of nitrogenous fertilizer to irrigated pastures on the production of grazing dairy cows, by M. Freer and D. E. Tribe 306
- The effect of nitrogen on non irrigated maize sown in pasture slits, by J. Strang and P. Broue 312
- The influence of sod-seeded legumes on the nitrogen economy of grassland soils at Lismore, N.S.W., by J. W. McGarity Residual response to urea fertilization, by E. G. Cuthbertson 287 295

Obituaries 83, 245

Pastures

- Changes in the soluble sugar contents of short rotation ryegrass during growth, by Jean S. Couchman 315
- The effect of an autumn application of nitrogenous fertilizer to irrigated pastures on the production of grazing dairy cows, by M. Freer and D. E. Tribe 306
- The effect of nitrogen on non irrigated maize sown in pasture slits, by J. Strang and P. Broue 312

- Growth rates of lucerne (Hunter River) and *Glycine javanica* in a tropical high-land environment, by G. W. Kyneur 314
- The history, characteristics and potential of Clare subterranean clover, by A. J. K. Walker and C. A. Neal-Smith 18
- The influence of sod-seeded legumes on the nitrogen economy of grassland soils at Lismore, N.S.W., by J. W. McGarity Responses to molybdenum three years after previous application on red basaltic soils on the far north coast of N.S.W., by F. G. Swain 51
- Sorghum alnum* Parodi—a valuable summer-growing perennial grass, by J. Griffiths Davies and L. A. Edye 117

Phosphorus

- The loss of applied phosphorus and sulphur from soils under pasture in W.A., by F. J. Hingston 209
- The microbial decomposition of sugar and its effect on phosphate solubility, by S. M. Bromfield 67

Plant analysis

- Changes in the soluble sugar contents of short rotation ryegrass during growth, by Jean S. Couchman 315
- Microdetermination of sulphur in plant material, by O. Iismaa 136

Plant hormones

- Inhibition of rooting by maleic hydrazide, by P. May 304

Plant nutrition

- Lateral movement of fertilizer sulphur, by N. J. Barrow and K. Spencer 208
- The magnesium supplying power of glazed porcelain pots, by F. J. Roberts 298

Plant pathology

- Bacterial blight of cotton in North Western Australia, by N. J. Thomson and J. J. Basinski 297
- Black ringspot disease of crucifers, by R. J. Conroy 64
- Nemagon and Vapam for the control of root knot of field tomatoes, by M. R. Sauer and J. E. Giles 138
- Plant virology in Australia, by L. L. Stubbs 11

Population

- Must people starve in the twentieth century, by R. H. Greenwood 184

Rhizobium

- Legume bacteriology in the tropics, by
D. O. Norris 202

Science

- The contribution of science to the future
of agriculture, by I. Clunies Ross 31

Sheep

- The effect of supplementation with urea
and molasses on the liveweight, appetite
and wool growth of sheep, by J. B.
Coombe 299
The Poll Dorset, by C. H. S. Dolling 259
The Poll Merino, by C. H. S. Dolling 109
The producer's view of the next twenty-
five years, by W. A. Gunn 41

Soils

- An air-pycnometer for field use, by C. V.
Malcolm 223
The field determination of soil reaction,
by M. Raupach and B. M. Tucker 129
Heat conduction and temperature profiles
in air and soil, by C. H. B. Priestley 94
Useful correlations between results of
fertilizer trials and other field data, by
C. B. Wells 273

Sorghum

- Sorghum alnum* Parodi—a valuable
summer-growing perennial grass, by J.
Griffiths Davies and L. A. Edye 117

Subterranean clover

- The history, characteristics and potential
of Clare subterranean clover, by A. J. K.
Walker and C. A. Neal-Smith 18

Sulphur

- Lateral movement of fertilizer sulphur,
by N. J. Barrow and K. Spencer 208
The loss of applied phosphorus and sul-
phur from soils under pasture in W.A.,
by F. J. Hingston 209
Microdetermination of sulphur in plant
material, by O. Iismaa 136

- Talks 77, 145, 229, 327

Temperature

- Heat conduction and temperature profiles
in air and soil, by C. H. B. Priestley 94

- Thesis summaries 71, 127, 188, 201, 321

Tobacco

- Occurrence, spread and severity of blue
mould, *Peronospora tabacina* Adam, of
tobacco in field plants, by A. V. Hill 55

Vegetables

- Black ringspot disease of crucifers, by
R. J. Conroy 64
Nemagon and Vapam for the control of
root knot of field tomatoes, by M. R.
Sauer and J. E. Giles 138

Vermín control

- The use of *Botulinus* toxin as a poison
for Kangaroo (Marloo) control in W.A.,
by D. Gooding 141

Vines

- Fermentation of the cold dip used for
drying sultanas, by R. J. L. Martin and
M. Grncarevic 221

Viruses

- Black ringspot disease of crucifers, by
R. J. Conroy 64
Plant virology in Australia, by L. L.
Stubbs 11

Weeds

- The control of water couch, *Paspalum*
distichum L, in irrigation channels by
3-Amino 1,2,4-triazole (Amizole), by
E. Levi 62

Wheat

- Residual response to urea fertilization,
by E. G. Cuthbertson 295

Wool

- The effect of supplementation with urea
and molasses on the liveweight, appetite
and wool growth of sheep, by J. B.
Coombe 299
Getting research results to woolgrowers,
by D. B. Williams 192
Wool fibre thickness frequency distribu-
tion in the staple: the proximal sample
compared with the whole staple, by
W. R. Lang and B. R. Wardle 294
Wool in the world market and in Aus-
tralia's economy, by R. B. McMillan 189

clude fewer or more areas of activity, depending on the type of agriculture, customs and tradition.

Accomplishments

Agricultural engineers generally work as part of a team where the accomplishments of the group are not always easy to credit to an individual member of that group. For example, a group of agricultural engineers in the United States recently announced the design, construction and testing of a successful castor bean harvester.

This appears to be an example of achievement by agricultural engineers, but they cannot claim sole credit for this development. Plant breeders modified the plant to fit it to machine harvesting, agronomists developed cultural practices including plant spacing, row width, fertilizer requirements, defoliation and irrigation recommendations to fit the plant for machine harvesting. Without the contribution of these specialists machine harvesting would not have been successful. On the other hand machine harvesting would not be a reality if agricultural engineers had not designed and built the harvester.

One must conclude that each specialist complimented the efforts of his associates. Credit for successful harvesting of castor beans belongs to all who contributed to this project. Any individual would be presumptuous to claim sole credit for developing successful machine harvesting of castor beans.

An indirect measure of accomplishments by agricultural engineers is implied in the following quotations.

"If United States farmers had used the methods of 1910 to produce the commodities turned out in 1950, the cost of production would have been something like 14 billion dollars greater than the actual cost of 30 billion dollars." (Soth 1957).

"... present day administrations of agricultural research no longer think of agricultural engineering as something which needs to be nursed, nurtured and guided to the extent that perhaps was necessary in former times. It is looked upon rather as a technical science capable of standing upon its own two feet, and of participating in agricultural investigations

on the same basis as the other essential sciences, such as chemistry, physics, bacteriology, economics, etc." (Trulinger 1940).

In the first six months of 1959 the Journal of the American Society of Agricultural Engineering contained 33 papers describing some of the current work in the United States. The topics covered included:

- Wheat harvesting machines and methods
- Irrigation systems
- Bulk milk coolers
- Evaluation of intense storms
- Building codes for Agriculture
- Hay pelleting
- Apple storage structures
- Land farming
- Solar energy
- Swine environment studies
- Measuring hydraulic conductivity
- Tractor transmissions
- Canal linings
- Applying soil fumigants
- Farm buildings of glass-fiber plastics.

Problems suggested by these and other topics have yielded to diligent inquiry by agricultural engineers and their associates. United States Agriculture, as an industry, has progressed largely because of the accomplishments of trained and competent workers, including engineers, dedicated to the study and solution of agricultural problems.

For those who insist on impressive lists of accomplishments this exposition will be unsatisfactory. However, it is my personal feeling that any such list would be misleading and perhaps unduly boastful.

Australia and Agricultural Engineering

- Is there a real need for agricultural engineering in Australia?
- If there is a need, what action should be taken to encourage the development of this professional group?

It would be most improper for a visitor to Australia to answer either of these questions. This is an Australian matter which must not be solved by imported "experts". Visitors are too often prone to suggest development along lines

similar to the familiar ones in their home countries. Too often these suggestions are out of harmony with Australian needs, desires and resources. The agricultural industry and its supporters in Australia are the only ones who can supply valid answers to these questions. This comment should not preclude the need for being well informed about the developments in other countries.

The agricultural industry in most other progressive countries has been enthusiastic in its support of agricultural engineering. This profession in turn has contributed to the growth of

a prosperous agriculture. What of the future of agricultural engineering in Australia? This is for the agricultural industry and its supporters to decide. To read Vasey (1953) again would be an excellent first step toward answering these two questions.

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Book Review

Elementary Soil and Water Engineering

By G. O. Schwabb, R. K. Frevert, K. B. Barnes and J. W. Edminster

J. Wiley and Sons, Inc.: New York, Chapman and Hall Ltd.: London.

This book, written primarily for students in agriculture at college level, covers, as the number of collaborating authors might indicate, a variety of subjects including simple surveying, soil and water conservation, tile drainage and sprinkler irrigation. Approximately one third of the book is devoted to the nature and prevention of soil erosion in America although most of the information and recommended control methods are also pertinent to Australian conditions.

There is a list of problems for the student to work

out for himself at the end of each section and the book concludes with exercises in practical field work. The treatment of most subjects lives up to the authors intentions although flood irrigation is somewhat neglected and the student will have to look elsewhere for elementary instruction.

The book is handsomely produced, contains many useful references, a good index and should give college students a satisfactory introduction to the main topics, particularly soil conservation.

A. WEBSTER

THE AGRICULTURAL RESEARCH INSTITUTE WAGGA WAGGA

A. T. PUGSLEY

The association of the New South Wales Government with agricultural research dates from 1890, the year of foundation of the Department of Agriculture. Soon after, in 1892, the Agricultural Experiment Farm at Wagga was established for the purpose of providing officers with facilities for field experimental work. Notable among the early workers were W. J. Farrer, N. A. Cobb and F. B. Guthrie, all of whom made significant contributions to agriculture, demonstrating at the same time the effective way in which the related basic sciences could be brought to bear on practical problems.

For over 60 years investigations at Wagga were concerned with field studies, with any associated chemical or biological work being carried out in the Department's laboratories at Sydney. During this period other institutions were established, notably the University of Sydney, the C.S.I.R. followed by the C.S.I.R.O. and more recently the Universities of New England and New South Wales. The functions of these institutions differ from those of the Department of Agriculture in that emphasis centres upon research in the more basic sciences relating to agriculture. The Universities, of course, have the sole responsibility for tertiary education in the various sciences concerned.

The responsibility of the N.S.W. Department of Agriculture lies primarily in the application of research to farm problems although of course, this may involve basic studies as well. The original incentives derive from farm problems and when the work is completed the Extension service of the same Department undertakes the responsibility of taking the research results to the farming community. The

close association between research and extension officers brings benefits to both services.

The Agricultural Research Institute at Wagga had its origins during the early post world war II years, a period which brought many changes in crop and pasture husbandry in southern New South Wales. Soon after his appointment as Minister for Agriculture in 1944 the late E. H. Graham considered that agriculture in the southern part of the State might be better served through the establishment of a research institute in a provincial centre. In this way it would be possible to more closely associate laboratory research with field investigations. At this time, too, the need for further research to improve the quality of wheat and flour was recommended by the Kinsella Industrial Commission of 1945.

The decision to establish a Wheat Research Institute at Wagga was made by the N.S.W. Government following recommendations to the Minister by a committee representing the various interests within the wheat industry.

During erection its scope was widened to embrace all aspects of agriculture and the name was changed to Agricultural Research Institute. The building was officially opened by the Minister for Agriculture and Food Production—Mr. E. H. Graham, on October 30, 1954.

The Institute building with a combined laboratory, office and storage space of 10,000 square feet is located directly opposite the Agricultural College buildings and some six miles from the City of Wagga (population 20,000). Thus situated research workers and

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The Agricultural Research Institute, Wagga Wagga.

their families have access to educational facilities and social amenities in the city, which also provides an adequate reservoir of labour for the recruitment of assistant laboratory and field staff. In return the research centre can contribute in a significant way to the cultural development of the city itself.

Facilities for field experiments are provided on the College farm, at Temora and Condo-bolin Experiment Farms and on selected private properties throughout the region.

Administration

The Institute is financed from State Government funds and since 1958 has been supported by grants from the N.S.W. Wheat Industry Research Committee and the Federal Wheat Research Council. It is administered separately from other Divisions and Branches of the Department and functions as a unit of Central Administration.

Research programmes are reviewed annually by a Technical Advisory Committee comprising senior officers of the Department with co-opted representatives of the C.S.I.R.O. and Bread Research Institute. In order that the work of the Institute may be linked with that of associated industries, an Institute Advisory Committee has been formed comprising the Director as Chairman and representatives from the wheat growing, milling and bread manufacturing industries.

Liaison between the Institute and the Advisory Services of the Department is effected

through the Southern Region Advisory Committee of which the Director is a member.

Research Programmes

During the early years of establishment the research programmes have centred around investigations of soil fertility, cereal chemistry, plant pathology and physiology, the genetics and breeding of wheat, oats and pasture plants and weed control.

Since 1950 the acreage of sown pastures in the South West Slopes and Riverina has increased more than three fold to a figure now approximating four million acres. At the same time the area under wheat has declined sharply. Much of the Institute's work bears directly on problems arising from this changed pattern of land use.

Top dressing of pastures with superphosphate and a lowered intensity of cropping have increased soil nitrogen levels and improved soil structure. In a general qualitative way we know a little of how the higher fertility levels affect yields and the quality of subsequent wheat crops, of their effect on the growth and control of skeleton weed and of the shift in emphasis of the various organisms responsible for take-all and root rots of cereals. Research programmes have been designed with a view to understanding the nature of these interactions and of measuring the magnitude of their effects.

The widespread use of clover dominant pastures has highlighted the need for better

pasture grasses and more productive grazing oat varieties and both these aspects of plant improvement work are receiving attention. It has not yet proved practicable, however, to initiate animal husbandry studies which, in view of the growing importance of the livestock industry in southern N.S.W., should be associated with work of this nature.

The responsibility for wheat improvement in southern New South Wales is vested in the Institute and breeders are located at Wagga and Temora. Quality considerations are of prime importance and the close day by day association of the wheat breeders with cereal chemists is a feature greatly valued by both groups. The chemistry section is equipped with excellent milling and test-baking facilities as well as physical dough testing equipment, and research studies are conducted concurrently with routine quality assessments from breeders' and agronomists' trials. In a similar way basic studies of disease and cold resistance and phasic development are directly related to the wheat breeding programmes.

Wherever possible steps are made to link the regional research programmes with those of a more basic nature which are conducted by the C.S.I.R.O. in Canberra. The recent collaborative work with cereal yellow dwarf and sub. clover stunt virus diseases may be cited as examples of such co-operation.

Research Staff

In establishing the Institute it was at once appreciated that agricultural research of the kind envisaged was essentially long term in nature demanding a high degree of staff stability if continuity of the various programmes was to be ensured. Adherence to three basic guiding principles have helped to achieve this. Briefly, these principles are that research officers should be fully qualified for the job, contented and free to pursue their work free from undue distractions, and should possess a "career range" in research with opportunities for advancement to senior positions.

At present the staff at Wagga consists of fourteen research officers (including one from C.S.I.R.O.), fourteen technical and field assistants and two clerical officers. In addition two research officers and two assistants are located at Temora Experiment Farm.

The majority of the staff are senior experienced officers and with their programmes now well established steps are being taken to recruit junior staff for each of the sections. In this way it is hoped to provide in-service training facilities not only for the Institute but for other branches of the Department as well. The objective over the next five years is a total research strength of approximately twenty officers which is regarded as a minimum size for a regional research group.

With such a unit it is possible to cover most regional problems and to arrange for their discussion at regularly held staff seminars. Flexibility in the use of plant and equipment and in the employment of assistant technical staff can be readily achieved and efficient use made of library facilities and clerical assistance.

The individual members of the group have their own special interests and, because of their relative isolation, it is important that they be encouraged to maintain a close association with their colleagues at other centres. Frequent visits to and from these centres, attendance at specialist conferences, as well as opportunities for overseas travel help to achieve these ends.

The Future

It is the view of those associated with the new venture at Wagga that a Research Institute properly constituted is perhaps the most effective way of approaching modern day research problems of an agricultural region. It is hoped that the results which accrue over the next ten years will justify this point of view and set a pattern for similar institutes elsewhere in Australia.

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COULD DUNG EATING INSECTS IMPROVE OUR PASTURES ?

G. F. BORNEMISSZA

The value of farmyard manure and animal droppings to pastures and crops is well recognized. In England and on the Continent where stall feeding of animals is practised, it is common to plough a heavy dressing of farmyard manure into the soil. At the time of application, decomposition of this manure has already been initiated by organisms, such as bacteria, nematodes, springtails, and mites.

In Australia, this system of manuring is usually not practicable. On the majority of farms the excreta from grazing animals is the only return of nutrients to the pasture. This return is potentially valuable in terms of plant nutrients (see Table 1), and compares more than favourably with artificial fertilizers (see Table 2). The extent of this return can be judged from the fact that domesticated animals in Australia void approximately 33 million tons of dung (dry weight) annually.

However, this potential is not sufficiently exploited in Australia. Here, the dung remains on the surface, and becomes hard and dry. In this way much of its nutritive value is lost. This is due mainly to the absence of coprophagous insects which in many other countries

(where domesticated animals are indigenous) bury the dung and hasten its decomposition. Although a number of our beetle species (e.g. *Onthophagus* spp., *Aphodius* spp.) are attracted to droppings of cattle, sheep and horses, they actually seldom dispose of it. Probably this is due to the difference between the droppings of the native mammals to which the beetles are adapted and that of domesticated animals. The size, structure, and chemical composition of the droppings of domestic animals may militate against their disposal by native beetles. The incorporation of this dung into the soil is therefore very slow and much of it litters the pastures for years.

The Losses

In many ways the prolonged presence of dung has an effect on the pasture somewhat like a noxious weed. However, unlike weeds, the presence of dung pads tends to escape attention. If the pads are made conspicuous as in Figure 1, their extent becomes impressive.

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TABLE 1

Value of dung and urine from eight wethers per acre per annum (Grasslands, N.Z.) expressed in pounds of artificial fertilizers. (After Levy (1955)).

Source	Sulphate of Ammonia, lb	Superphosphate, lb	Carbonate of Lime, lb	30% Potash Salts, lb
In urine	1,996	Trace	Trace	1,670
In dung	723	683	268	197
Total	2,719	683	268	1,867



Figure 1—Cattle pads made conspicuous by paper bags and stakes in a paddock within an area of 1 sq. chain. Bagged pads were dropped 3 weeks previously. Staked pads were dropped during previous grazing 5-6 months before this photograph was taken. (Boolarra, Vic., March 1959).

The area covered by the pads is quite substantial. In order to determine the area covered by pads, observations were carried out at Boolarra, Victoria. The average size of cattle pads measured was 1,000 sq. cm. when cattle fed on green grass, 800 sq. cm. on dry feed, and about 1,200 sq. cm. when fed on silage or potatoes.

Grass growth is prevented on the area covered, and a further loss results from the zone of rank growth around the pads (see Figure 2) which is not grazed by cattle for at least a year. Weed growth is also encouraged. In this way each pad causes the loss of an average area of 465 sq. in. As the average number of pads dropped by adult cattle per

day is 10, a minimum of 365 sq. yd. of pasture or approximately 7.5 per cent. of an acre is covered by dung from one cow annually. Taking the unpalatable rank growth also into account, five cows would decrease the effective area of pasture by one acre over a period of one year.

The mechanical dispersion of cattle pads in pastures is practised only in dairying and intensive beef cattle areas. However, this measure is of limited value, unless carried out immediately after cattle have been removed from the paddock. Even so, the accumulation of organic debris on the surface cannot be prevented by harrowing alone and a rise in soil acidity can be expected.

In actual practice a lag occurs in the mechanical dispersion of the droppings. This results in a loss of production conservatively estimated at 30 per cent., so that 5 million dairy cattle would reduce the effective acreage of pasture by at least 300,000 acres annually. This acreage would support about 100,000 dairy cows worth in excess of £3,000,000, and yielding more than £2,500,000 in dairy products per annum. The losses suffered by the beef cattle and sheep industries are also important.

The Palliative

Cattle and sheep were introduced to Australia without the diverse insects which have become specialized in burying and decomposing their manure. The most effective of these insects are the coprophagous beetles from the family Scarabaeidae. This is a very large family, contain-

TABLE 2

Hay yields after different systems of manuring at Garforth Experiment Station, England. (After Moore (1951)).

Manuring: 1912-1926	Yield per acre
Dung each year (6 tons per acre)	45.00 cwt.
Dung in alternate years	37.75 cwt.
Dung alternating with nitrate of soda	41.75 cwt.
Complete fertilizers each year	
Nitrate of soda 1 cwt. per acre)	29.25 cwt.
Superphosphate 2 cwt. per acre)	29.25 cwt.
Katnit 3 cwt. per acre)	29.25 cwt.
Nitrate of soda (1½ cwt. per acre) each year	23.25 cwt.
No manure	14.25 cwt.



Figure 2—Rank growth surrounding 6 months old cattle pad was avoided by cattle during recent grazing. (Boolarra, Vic., March 1959).

ing several thousand species which feed exclusively on various kinds of animal droppings (e.g. subfamily Coprinae and Geotrupinae). These beetles are widely distributed, although they favour the warmer regions of the globe. The variety and abundance of species of any areas is, however, directly correlated with that of the native mammalian fauna. It is not surprising, in view of the great herds of game (many species are related to domesticated animals), that the greatest diversity of these beetles occur in East and South Africa. Even where these herds have been exterminated by man (e.g. the southern parts of South Africa), many species of coprophagous beetles are still abundant, having adapted themselves to the dung of introduced animals such as cattle, sheep and horses. During the warmer months of the year, many species are so abundant, despite their natural enemies, that most of the cattle pads are cleaned away within hours or days after they are dropped.

In view of this, the possibility of introducing a suitable beetle fauna into Australia should be investigated. These beetles will ensure the removal of large amounts of cattle and sheep droppings, thereby reducing pasture wastage.

The Habits of Dung Beetles

The beetles in question are strong fliers favouring warm to hot, sunny days—which are a feature of the Australian climate. They are also fast and powerful diggers in any type of soil. The majority frequent fresh manure, often

only while it is still soft. They quickly burrow under and around the droppings, taking lumps of dung into their tunnels for themselves and their larvae. A wide range of other species knead balls out of the soft dung and roll them away to bury in the soil in places suitable for their offspring.

As stated previously, these beetles are particularly active in East and Southern Africa where the climate is in many respects similar to that of Australia. Hence, there should be good prospects of finding, introducing, and establishing, suitable species in Australia.

The Benefits

If these beetles become numerous in Australia, the following benefits could accrue:

- The rapid incorporation of dung into the soil during the warmer months of the year.
- Improved retention of volatile nitrogenous, and other constituents of dung in the soil.
- Accelerated decomposition of the dung as a result of digestion by the beetle and its larvae.
- Reduced accessibility to sheep and cattle of the infective stages of parasitic worms.
- A reduction of breeding habitats for the buffalo fly, bush fly and house fly.
- An improvement in the friability, water permeability, and water holding capacity of the soil.

Acknowledgments

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The Occurrence of Barley Yellow Dwarf Virus in New South Wales

The aphid-borne, non-mechanically transmissible virus disease of cereals caused by barley yellow dwarf virus (BYDV) (Oswald and Houston 1951) was first reported from New South Wales in October, 1956, in wheat and oat variety trial plots at Tamworth (Smith 1957, 1959). Subsequently, Smith attributed a stunted, yellowed condition in aphid-colonized wheat plants at the Agricultural Research Institute, Wagga Wagga, to BYDV infection. He observed similar symptoms in wheat at Canberra, A.C.T., and in wheat and orchard-grown oat crops in Tasmania (Smith 1959).

Identification of BYDV by Smith was based on symptom expression: no transmission tests were conducted. Such tests, confirming the local occurrence of this disease, have since been carried out at the Agricultural Research Institute, Wagga Wagga and at the Division of Entomology, C.S.I.R.O., Canberra. Further work with BYDV is in progress.

Preliminary Aphid Transmission Tests

Colonies of *Rhopalosiphum maidis* (Fitch), an established vector of BYDV (Oswald and Houston 1951) were found on stunted, chlorotic, glasshouse-grown, hybrid wheat plants at the Agricultural Research Institute, Wagga Wagga, in the winter of 1958. The symptoms exhibited by these plants closely resembled those observed previously in summer-grown wheat at the Institute and attributed by Smith to BYDV infection.

Five, mature, apterous aphids were transferred to each of 40 Belar oat seedlings at the 2-4 leaf stage and allowed to feed for 24 hours. Ten seedlings were kept free from aphids. Within 16-18 days, 80 per cent. of the inoculated seedlings developed symptoms charac-

teristic of BYDV infection as described by Oswald and Houston (1951, 1953). Diffuse yellowish blotches appeared near the tips of young leaves and older leaves developed a reddish-purple pigmentation. Newly emerged leaves often showed a longitudinal chlorotic striping, but serration of the leaf edges, reported by Oswald and Houston (1953), was rarely observed. None of these symptoms developed in any of the control seedlings. At maturity infected plants were 5-8 in. shorter than the controls, produced a higher proportion of blasted florets and yielded, on the average, 44 per cent. less grain.

Field Observations

During the winter of 1959 barley yellow dwarf was observed, for the first time by the authors, in commercial cereal crops in southern New South Wales.

Recorded initially in a 54 acre crop of Belar oats at Yarragundry, near Wagga Wagga, the disease was later seen in wheat crops in this district, in oat crops at Mangoplah, Bethungra, Temora and Cootamundra, and in wheat crops at Mangoplah and Wagga Wagga.

Except for the crop of Belar oats at Yarragundry, in which infection increased progressively from approximately 8-10 per cent. in mid-July to an estimated 50 per cent. by late August, none of these crops was seriously affected by yellow dwarf. Although isolated diseased plants were occasionally observed, BYDV infection in oats occurred characteristically in well defined semicircular patches, with which *Rhopalosiphum padi* (L.) (syn. *R. prunifoliae* (Fitch.)), another aphid vector of this virus (Oswald and Houston 1951), was associated. Within these patches (Figure 1) which varied in diameter from one foot to ten feet or more, the plants were extremely stunted and abnormally coloured. Older leaves were a yellow to orange colour and often showed a deep reddish-purple pigmentation. A characteristic longitudinal chlorotic striping was common in younger leaves, many of which were serrated at the edges.

During the season a proportion of the earliest infected plants in the centre of the patches died. Of those that survived, some failed to head and others produced panicles with a



Figure 1—BYDV infection occurring in patches in a crop of Belar oats at Yarragundry, N.S.W., July, 1959.



Figure 2—BYDV infected Belar oats (left) and uninfected control plants of same age (right). Photographed 2 months after inoculation by *Rhopalosiphum padi*.

high percentage of blasted florets. A similar pattern of infection was observed in wheat, where infected plants were stunted and yellowed but showed none of the red or purple pigmentation that was common in oats. Longitudinal chlorotic striping was very apparent in younger leaves, which yellowed from the tips as they aged. Serration of the leaf margins was occasionally noted.

Identity of the Virus

Two colonies of *R. padi*, collected with infected Belar oat plants from Yarragundry and Mangoplah, were used in transmission tests at Wagga Wagga during the winter of 1959. Three to five mature apterae per plant were used in each test and allowed to feed for 48 hours on wheat, oat, and barley seedlings at the 1-2 leaf stage. In each inoculated series of plants a high percentage of transmission of BYDV was recorded

(Table 1). None of the controls showed any evidence of infection.

Symptoms, which appeared 15-17 days after inoculation, were similar to those described by Oswald and Houston (1951, 1953). Extreme stunting, which was very noticeable in oats (Figure 2) and barley, was not so pronounced in wheat. All three cereals showed chlorosis and distortion of the new growth and characteristic longitudinal green and yellow striping in many of the younger leaves, but only oats developed a reddish-purple pigmentation. Serration of the leaf edges was common in oats and barley but rare in wheat. Necrosis of the growing tips was observed in barley and oats but not in wheat.

Small-scale transmission tests, similar to those described for *R. padi*, were conducted

TABLE 1

Transmission of BYDV to wheat, oats and barley by Rhopalosiphum padi (L.).

Treatment	Wheat var. Ford		Oats var. Belar		Barley var. Trabut	
	No. plants	Per cent. infected	No. plants	Per cent. infected	No. plants	Per cent. infected
<i>Inoculated</i>						
Aphids ex. Yarragundry	18	88.9	27	100.0	19	94.6
Aphids ex. Mangoplah	8	100.0	9	100.0	9	100.0
<i>Control</i>	19	0.0	18	0.0	20	0.0

with *R. maidis*. Mature apterae from colonies occurring naturally on BYDV infected, glasshouse-grown wheat were transferred (three per seedling) to each of 20 seedling oat plants (var. Belar). A second set of ten seedlings was inoculated, using aphids taken from glasshouse-grown oats which also showed evidence of BYDV infection. Seventy and eighty per cent., respectively, of these two series of seedlings subsequently developed typical symptoms of BYDV which did not appear in any of the control seedlings.

During the winter of 1959 a stunted wheat plant from Wagga Wagga was removed to Canberra and a colony of virus-free *R. padi* allowed to breed on it. Three aphids per plant were fed for three days on each of 15 test plants of Blackhulless and Proctor barley and Blenda, Victoria and Belar oats. In each case 80-100 per cent. of test plants developed typical symptoms as described by Oswald and Houston (1951, 1953) and Watson and Mulligan (1957). A similar test from oat plants collected at Yarragundry resulted in the development of typical symptoms on Belar and Victoria oats and on Blackhulless barley. Test plants, to which virus-free *R. padi* were transferred from a healthy wheat plant, showed no disease symptoms.

Negative results were obtained from mechanical transmission tests, to 400 cereal plants, conducted at Wagga Wagga and Canberra during 1958 and 1959.

From the symptom expression data, the pattern of field occurrence, transmission by *R. padi* and *R. maidis*, and the failure to obtain mechanical transmission it is concluded that the disease observed in wheat and oats is caused by BYDV as described by Oswald and Houston (1951, 1953).

Aphid Vectors

Of the seven aphid vectors of BYDV (Oswald and Houston 1951, 1953; Watson and Mulligan 1957), *R. padi* and *R. maidis* were observed in infected wheat and oat crops and on infected glasshouse-grown cereals (wheat, oats and barley) in the winter of 1959.

The occurrence of a third aphid, *Macrosiphum avenae* s-sp. *miscanthi* Takahashi, was also noted in association with BYDV infected plants. In comparative glasshouse tests *M. avenae miscanthi*, not previously recorded as a vector, proved as efficient as *R. padi* in transmitting BYDV to seedlings of Blackhulless barley.

R. padi was the most commonly encountered species in the field and apart from its occurrence on cereals was found on barley grass (*Hordeum leporinum* Link) and Wimmera ryegrass (*Lolium rigidum* Gaud.).

Acknowledgements

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Two Seed borne Fungi of French Bean — *Phaseolus Vulgaris* L

Two fungi which are commonly found attacking French beans in New South Wales are *Rhizoctonia* sp. * and *Sclerotinia sclerotiorum* (Lib.) de Bary. Both can cause a stem rot of young plants and can also attack the leaves and pods of older plants especially those touching the soil or near soil level. Occasionally, rotting of the upper parts of plants is caused by *S. sclerotiorum*, probably resulting from ascospore infection. Both fungi are usually seen during warm weather and both require moist conditions for their best development.

During the past year both of these fungi have been found carried with bean seed grown on the Far South Coast of N.S.W. This is the first time this has been found in N.S.W. although other workers, mainly in the U.S.A., have reported seed carry-over of both fungi on several occasions.

Literature Review

Hedgecock (1904) appears to have been the first to record seed-borne *Rhizoctonia* on any crop. He found mycelium and sclerotia present in the seed coat of beans, resulting from infection of pods in contact with the soil. Crosier (1948) reported that about 0.5 per

* The exact identity of the fungus concerned is not known. Recently Flentje (1956, 1957) studied several isolates of *Rhizoctonia solani* Kühn and found that he could separate them into two groups on the basis of the type of perfect stage produced and on cultural and morphological characters. He considered these two groups to be two closely related species, *Pellicularia filamentosa* (Pat.) Rogers and *P. praticola* (Kotila) Flentje. As it is not known in the present case whether the *Rhizoctonia* from bean seed corresponds to *P. filamentosa* or *P. praticola*, and as the name *R. solani* Kühn is generally accepted as the name of the imperfect state of *P. filamentosa*, the present fungus is called simply *Rhizoctonia* sp.

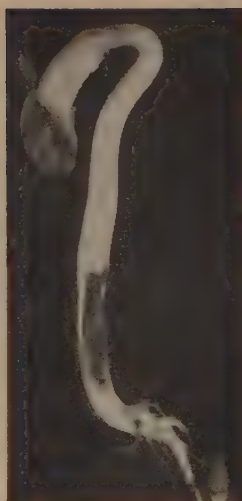


Figure 1—Hypocotyl lesion on bean seedling caused by seed-borne *Rhizoctonia* sp.

cent. of the seed lots he examined contained *R. solani* and later (Crosier 1950) he reported finding sclerotia of this fungus on seeds of red kidney beans from California. Leach and Pierpoint (1956) stated that 22 per cent. of the samples they tested from Idaho and California showed some seed transmission of *R. solani*.

S. sclerotiorum is listed by Doyer (1938) as carried with bean seed and Baker and Davis (1951) recorded finding sclerotia of this fungus in bean seed samples. Blodgett (1946), who studied the *Sclerotinia* disease of beans in Idaho, found that the fungus may be carried as sclerotia with seed samples and as mycelium in the seed. Hungerford and Pitts (1953) found a small amount (less than 1 per cent.) of seed transmission when seed from infected fields was planted the year following production. Only a trace of the disease was found in two year old seed and it was found that the majority of carry-over occurred in discoloured seed.

Noble, de Tempe and Neergaard (1958) list both fungi as carried in bean seed.

Present Findings

Rhizoctonia sp. seed carry-over was detected in three samples of seed during routine germination tests being carried out by the rolled towel method. When the seeds had



Figure 2—Seed blemishes from seed sample infected with *Rhizoctonia* sp. Unblemished seed on left.

germinated, sunken, light-brown watersoaked lesions were seen on the hypocotyls of a few seedlings (Figure 1). These lesions became a darker brown on drying. Mycelium typical of *Rhizoctonia* sp. was seen in them and the fungus was isolated readily in pure culture.

S. sclerotiorum was found in two samples of seed. When these were planted in sterilised soil, a few of the seedlings developed a watery rot of the hypocotyl, which began at the base of the cotyledons. The typical white mycelium and sclerotia of the fungus developed on the affected seedlings.

The above findings are summarised in Table 1.

Both the seed samples carrying *Rhizoctonia* sp. and those carrying *S. sclerotiorum* contained many more discoloured and weather-

damaged seeds than uninfected ones. In the *Rhizoctonia*-affected samples of Brown Beauty, the discolouration occurred as slightly raised darker-brown areas on the seed, in severe cases covering almost the entire surface (Figure 2). Only a small proportion of these blemished seeds gave rise to *Rhizoctonia*-affected seedlings and it was not possible to tell by a visual examination which seeds were infected by the fungus.

Similar blemishes were observed in the seed samples infected with *Sclerotinia*. However, a small percentage of seeds were seen with a different type of blemish. This occurred as lighter coloured slightly raised areas on the seed, usually surrounding the hilum (Figure 3). These areas were cream in colour shaded with a definite pink tinge in parts. As far as could be determined by hand sorting of seed,

TABLE 1

Results of examination of bean seed samples.

Variety	Locality Grown	Fungus contaminant	Percentage of seeds infected
Brown Beauty	Cobargo	<i>Rhizoctonia</i> sp.	Less than 1%
Brown Beauty	Bodalla	<i>Rhizoctonia</i> sp.	Less than 1%
Hawkesbury Wonder	Narooma	<i>Rhizoctonia</i> sp.	Less than 1%
Brown Beauty	Kiah	<i>Sclerotinia sclerotiorum</i>	Less than 1%
Hawkesbury Wonder	Bega	<i>Sclerotinia sclerotiorum</i>	1-3%



Figure 3—Light coloured blemish surrounding hilum on seed infected with *Sclerotinia sclerotiorum*. Healthy seed on left.

it was only seeds showing these latter blemishes that produced *Sclerotinia*-infected seedlings.

This same type of seed discolouration has been seen recently in seed taken from pods harvested under damp conditions and affected with *Sclerotinia* rot. Varying degrees of seed destruction by the fungus were observed, slightly affected ones having only a small discoloured area, usually around the hilum, and severely affected ones being completely discoloured and much lighter in weight than normal seeds.

Discussion

Although this is the first time that transmission of *Rhizoctonia* sp. and *S. sclerotiorum* with bean seed has been reported in N.S.W., it is most probable that it has been occurring in small amounts for some years. Observations during the past year indicate that the degree of seed transmission is probably related to the weather conditions prevailing as the seed is maturing, just before harvest. Under damp conditions, more seed infection occurs than when it is dry.

Both fungi are quite widely distributed in N.S.W. and the amount of seed carry-over that has been found so far is unlikely to be serious, except where the diseases may be introduced into land previously free of them. Menzies (1952) suggests that it was probable that infected or contaminated bean seed was the means by which *Sclerotinia* was introduced

into newly irrigated areas of the Columbia basin.

Acknowledgments

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A Comparison of Rock Phosphate and Superphosphate as Sources of Phosphorus on a Black Earth

As a result of a world-wide shortage of elemental sulphur and the accompanying restriction in superphosphate manufacture, and in view of earlier claims (discussed by Rossiter and Ozanne 1955) that subterranean clover is unable to utilize tricalcic phosphate, a number of trials throughout Australia were planned in 1952 to test the value of rock phosphate as a source of phosphorus to subterranean clover. Some results of these have already been published (McLachlan 1954; Rossiter and Ozanne 1955).

The results of a field experiment to compare the availability of the phosphorus in finely-ground rock phosphate with that in superphosphate at Armidale in northern New South Wales are presented below.

Experimental Methods

The basis of the experiment was a comparison between rock phosphate applied at three rates (4, 8, and 16 cwt per acre) and superphosphate at three rates (2, 4, and 8 cwt per acre).

Plots were 20 x 15 links in size, and six replications of the seven treatments were arranged in balanced incomplete blocks. A sulphur carrier (sodium or calcium sulphate)

was used to supply about 25 lb of sulphur per acre in the autumn of 1952, 1953, and 1954. The phosphorus treatments were broadcast by hand once only (June 4, 1952). The rock phosphate sample was similar to that used by McLachlan (1954).

An unfertilized area of subterranean clover pasture (*Trifolium subterraneum* L. var. Tallarook), sown in March 1950, was selected for uniformity. The principal associated species was *Agrostis avenacea* Gmel. The clover showed the stunting and purplish colouration characteristic of phosphorus deficiency. The soil is a Black Earth, having a pH of about 6.5 in the surface four-inches and becoming alkaline at about twelve inches.

Results

A. Dry Matter Yields of Pasture

1952: Marked improvement in the clover growth on the superphosphate treated plots was observed nine weeks after application of the fertilizers but the rock phosphate plots showed only slight improvement at this time. The difference at this stage may well have been a reflection of the greater solubility of the superphosphate and its more rapid penetration to the root zone.

Seasonal conditions were very favourable in 1952 and yield cuts at the end of the season showed that rock phosphate and superphosphate produced significant effects at all levels of application (Table 1). Botanical separations revealed that responses were confined to the clover fraction. The marked superiority of superphosphate as a source of phosphorus is clearly shown.

TABLE 1

Yields of a subterranean clover pasture in three seasons (in cwt per acre of dry matter).

Treatment	P. equivalent (lb/acre)	1952 Clover	Total	1953 Clover	Total	1954 Clover	Total
Nil	0	16.88	23.6	4.22	13.8	8.47	24.7
4 cwt R.P.	72	27.78	35.5	7.39	20.8	12.18	23.2
8 cwt R.P.	144	29.77	33.8	5.48	18.0	15.22	27.6
16 cwt R.P.	288	39.08	44.7	8.00	22.8	20.82	30.1
2 cwt Super	21.5	62.34	66.8	9.43	20.9	17.73	28.5
4 cwt Super	43	63.39	68.1	12.40	28.7	22.61	29.9
8 cwt Super	86	70.53	75.8	16.08	32.8	27.00	41.6
min. sig. diff.	P = .05	9.51	10.1	4.94	6.63	4.9	6.4
min. sig. diff.	P = .01	19.21	13.7	6.72	9.01	6.7	8.7

R.P. = rock phosphate
Super = superphosphate.

1953: Dry conditions restricted growth of both components but the seasonal rainfall distribution favoured the associated grasses. Significant responses were not established in each comparison but the superiority of superphosphate was again shown (Table 1). The non-clover fraction in this year showed small but non-significant responses to phosphorus (nitrogen now less limiting?).

1954: Although there was a dry winter in this year, clover growth was moderate and significant effects from both sources were recorded. Compared with the first year, the order of the response to superphosphate had declined somewhat, whereas that to rock phosphate was maintained. Non-legumes showed no responses in this season (Table 1).

B. Responses by Clover

As clover was the consistently responsive fraction of the pasture, the clover yields warrant further examination. The response curves (not presented here) when superphosphate was the carrier, showed good fit to the Mitscherlich form in each year. Those for rock phosphate were nearly linear in each year and it was necessary to use the maxima indicated by the superphosphate curves to derive the percentage responses to be presented later.

From the fitted curves, the dry matter yields at a series of arbitrary rates of phosphorus application were calculated for each carrier. The increments (treated minus untreated) are shown in Table 2. The value of rock phosphate relative to superphosphate (equivalent phosphorus basis), improved with time but even in the third year, rock phosphate was decidedly inferior.

C. Phosphorus Uptake by Clover

The clover tops were analysed for total phosphorus content in each of the years, and the uptake values confirm the greater availability of the phosphorus in superphosphate. Individual data are not presented but the comparison of 4 cwt rock phosphate with 8 cwt superphosphate (roughly equivalent in phosphorus content) summarizes the general findings. Over the three years, six times as much phosphorus was taken up by the clover tops from the superphosphate treatment as by those from the rock phosphate treatment.

D. Soil Phosphorus Levels

Acid-soluble phosphorus and adsorbed phosphorus (Williams 1950) in the surface four inches of soil were determined at the conclusion of each season of clover growth. With

TABLE 2

Dry matter increases in clover tops when fertilized with several rates of phosphorus applied as rock phosphate and as superphosphate (in cwt per acre).

Year	Treatment	Phosphorus Applied—lb P per acre				
		10	20	40	80	160
1952	Rock phosphate	1.4	2.7	5.1	9.2	15.3
	Superphosphate	30.4	42.7	49.6	51.0	51.0*
1953	Rock phosphate	0.2	0.3	0.6	1.3	2.6
	Superphosphate	2.6	4.7	7.9	11.5	13.7*
1954	Rock phosphate	0.5	1.1	2.1	4.0	7.5
	Superphosphate	4.8	8.5	13.4	17.8	19.8*

*160 lb P considerably exceeds observed range of application rates for superphosphate.

the exception of the highest rate of rock phosphate, no treatment caused any change in soil phosphorus below the surface inch. Values for the top inch are presented in Figure 1.

On the superphosphate plots, more phosphorus was held in adsorbed forms than as acid-soluble compounds, even though the initial carrier consisted largely of acid-soluble phosphorus. The amount of both forms of soil phosphorus at each level of superphosphate declined with time—untreated plots increased slightly, possibly as a result of contamination. By the end of the third season, the differences due to superphosphate level were very small compared with the initial effects. Much of this decline can be accounted for by plant uptake.

On the rock phosphate plots, larger amounts of acid-soluble phosphorus than adsorbed phosphorus were measured. Initially, the increases in both forms were comparable with those from an equivalent amount of phosphorus as superphosphate but the marked decrease in content observed with both forms in the case of superphosphate was not repeated in the rock phosphate plots. Levels of acid-soluble phosphorus and adsorbed phosphorus were sustained or even slightly increased over the period of observation.

Discussion

The results of Table 1 give the impression that the superiority of superphosphate over rock

phosphate wanes with time but the data in absolute terms do not lend themselves to comparisons because of seasonal influences. Some account of the latter is taken by considering the maximum response in each year and expressing the individual responses as a percentage of that maximum. For the nearly comparable treatments, 8 cwt superphosphate and 4 cwt rock phosphate, the superphosphate phosphorus declined from an effectiveness represented by a percentage response of 100 in 1952 to one of 91 in 1954; rock phosphate phosphorus maintained response at 18 per cent. over the

TABLE 3

Adsorbed phosphorus in surface inch of soil extracted by Bray's solution (0.025N.HCl + 0.03N.NH₄F) (in p.p.m. P).

Treatment	Sampling Date		
	28/1/53	25/3/54	9/2/55
Nil	3	3	4
4 cwt R.P.	3	6	4
8 cwt R.P.	4	8	4
16 cwt R.P.	5	11	6
2 cwt super	6	8	4
4 cwt super	8	11	6
8 cwt super	18	11	5

R.P. = rock phosphate.

Super = superphosphate.

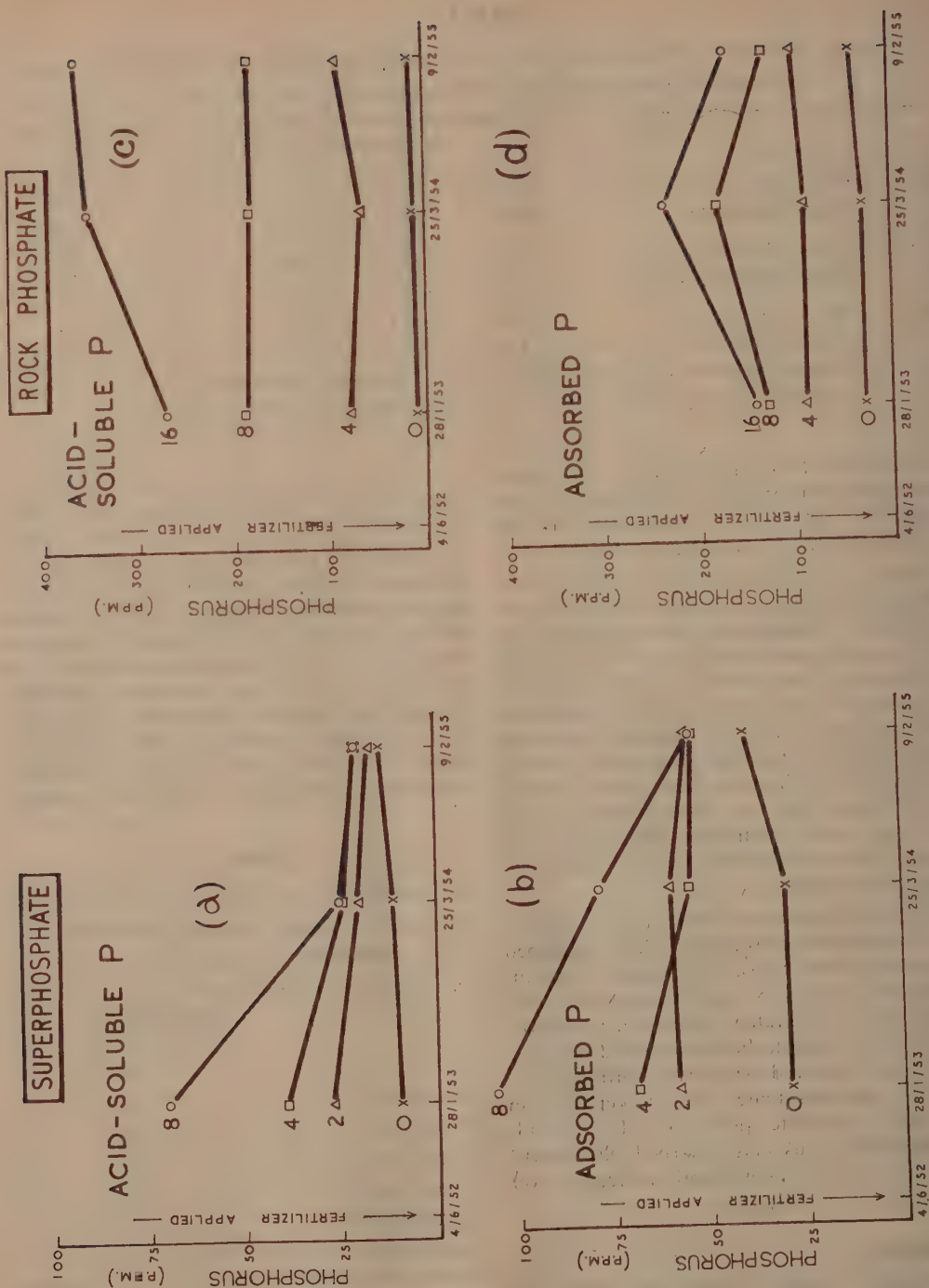


Figure 1—Soil Phosphorus levels in the surface inch under a range of rock phosphate and superphosphate treatments—phosphorus extracted by the method of Williams (1950).

three-year period. At half the above rates of phosphorus application, the corresponding percentage responses were 98 falling to 70 for superphosphate phosphorus, and 10 increasing to 15 for rock phosphate phosphorus.

The decline in the value of the superphosphate phosphorus was reflected in the acid-soluble phosphorus and the adsorbed phosphorus contents of the surface inch of soil. In contrast, the corresponding fractions on the rock phosphate plots suggest that levels were maintained over the period measured. However, there are important reservations in the case of rock phosphate. Acid extraction is recognised (Nelson *et al.* 1953) as providing an over-estimate of the amount of phosphorus from this source available to plants (Note levels in Figure 1c which proved to be grossly inadequate). Adsorbed phosphorus appears little better as a guide to availability (Figure 1d) as the values again are much in excess of corresponding values for superphosphate, which however, proved more effective.

On the other hand the extractant developed by Bray and Kurtz (1945) for use where rock phosphate residues are present, viz. 0.025N.HCl + 0.03N.NH₄F solution, gave a fairly accurate picture of the phosphorus available in the various treatments (Table 3).

The similarity of the trial reported by Rossiter and Ozanne (1955) with the present one permits certain comparisons. On the bases of yield responses, phosphorus uptake by clover and utilization of fertilizer phosphorus, rock

phosphate compared even less favourably with superphosphate at Armidale, New South Wales than at Kojonup, Western Australia. The heavy texture (through its effect on positional availability) and the near-neutral reaction (through its effect on chemical availability) of the Black Earth are the properties of likely significance.

Although the unit price of phosphorus in rock phosphate is only 2/3 that of the phosphorus in superphosphate, the much greater rates of application required would make its use uneconomic under conditions similar to those of the experimental area.

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Digestibility of *Medicago Tribuloides* (Barrel Medic) Pods

In the Mallee and Wimmera districts of Victoria, much attention has been paid in recent years to the development of suitable pasture legumes. *Medicago tribuloides* (barrel medic) is particularly suited to 10-16 inch rainfall

areas and is now widely grown in these districts. The resultant pods, or burr, are present in large quantities over the summer months.

Reports have been received from farmers that burr forms a valuable fodder reserve for sheep during the summer. A similar situation was referred to by Lang *et al.* (1952) who cited subterranean clover pods in the same capacity. To date, little is known about the feeding value of leguminous pods, although

trials involving the feeding of the seed of pasture legumes have been reported by Franklin and Powning (1942) and Suckling (1950, 1952).

To investigate the feeding value of whole pods, a digestibility trial was conducted at the Animal Husbandry Research Centre, Werribee, with pods collected from the Walpeup area in the Victorian Mallee. Information was also collected on the physical and chemical composition. A commercial strain of *M. tribuloides* was used.

Experimental

Five mature Corriedale wethers, in digestibility cages, were fed a diet consisting solely of *M. tribuloides* pods. The sheep were under orthodox digestibility trial conditions. After a 21-day preliminary feeding and settling-in period, collections were made for seven days.

Samples were taken from the bulk of the pods for:—

- dry matter determination,
- weight of 1000 pods,
- hard seed percentage,
- number of seeds per pod,
- weight of 1000 seeds,
- seed and hull percentage in the whole pod,
- chemical analysis of pods, seeds and hulls.

Faeces samples were taken for:—

- dry matter determination,
- chemical analysis,
- seed counts.

TABLE 1

Intakes and dry matter and organic matter digestibilities.

Sheep	Dry matter intake g per 7 days	Dry matter digestibility %	Organic matter digestibility %
1	6780	30	31
2	8350	31	32
3	4250	30	31
4	6460	28	30
5	7060	33	34
Average		30	32

Results

The sheep varied in their initial intake of the pods. Two of the sheep began eating reasonable quantities from the second day in the cages and consumed increasing amounts from then on; the remainder took up to ten days before eating in quantity. However, before the end of the preliminary period all intakes were steady, ranging from 600 to nearly 1200 gram of dry matter per day. Intakes, and dry matter and organic matter digestibilities are shown in Table 1.

TABLE 2

Chemical composition expressed as per cent. on dry matter basis.*

Sample	Crude protein	Ether-extract	Crude fibre	Ash	Nitrogen-free-extract
Whole pod	18.2	4.9	41.5	5.7	29.7
Seed	45.4	16.2	6.1	3.0	29.3
Hull	6.1	4.5	56.4	3.7	29.3

*Samples had a moisture content of 7.5 per cent.

Table 2 sets out the chemical composition of samples of whole pods, seeds and hulls. Soil contamination between the spines of the pods is common; the loss of some of this in threshing to separate the seeds from the hulls, no doubt accounts for the anomalous ash percentage figures.

TABLE 3

Apparent digestibility of the individual proximate constituents.

Sheep No.	Digestibility %			Nitrogen-free-extract
	Crude protein	Crude fibre	Ether-extract	
1	67.8	17.6	73.5	19.1
2	68.9	17.2	75.4	23.3
3	68.0	17.1	80.3	19.7
4	66.1	15.7	70.3	20.1
5	66.6	21.9	72.3	24.7
Average	67.5	17.9	74.4	21.4

In common with other legumes, seeds of *M. tribuloides* have a particularly high crude protein content and this leads to high intakes of crude protein, in this case ranging from 100 to 220 grams per day. Crude fibre intakes range from 250 to 490 grams per day. The digestibilities of the individual proximate nutrients are shown in Table 3. The low digestibility of crude fibre (18 per cent.) is indicative of the highly lignified nature of the hull fraction of the pod.

Some seeds pass through the animal without being digested and appear as whole seeds in the faeces. This aspect may be of some interest from the point of view of seed dissemination; data are presented in Table 4.

TABLE 4
Calculated seed intakes and outputs.

Sheep No.	Average no. of seed consumed per day, 1000's	Average no. of seeds defaecated per day
1	82.1	650
2	100.9	3160
3	50.0	120
4	73.8	1520
5	84.9	2020

Pods of *M. tribuloides* are, as suggested by the popular nomenclature, barrel-shaped, and greater in depth than diameter. Seeds are kidney-shaped, yellow and approximately 3 mm in length. Some of the physical characteristics are presented in Table 5.

TABLE 5
Physical characteristics of the pods and seeds.

Characteristic	Value
Average weight 1000 pods (g)	77.6
Average seeds per pod	6.1
Range of seeds per pod	4-9
Percentage hard seeds	97.2
Average weight 1000 seeds (g)	3.73
Percentage dry matter of whole pods as	
Seed	27.7
Hull	72.3

Discussion

The dry matter digestibility of *Medicago tribuloides* is low, but intakes by the experimental sheep used here were relatively high for a feed of this nature; by comparison, dried off summer annual pasture has been found to have a dry matter digestibility of around 40 per cent. with *ad libitum* intakes in the region of 400-450 grams per day (Pearce and Vercoe, unpublished data). Caged sheep generally eat less of a given diet than do grazing sheep; it is possible therefore, that, under favourable conditions, grazing intakes of pods may be quite substantial.

To date, conflicting reports have been received from farmers regarding the amount of burr eaten by grazing sheep. Some have reported finding large quantities of burr in the rumen when sheep have been slaughtered, while others have reported finding little or none at all. More observations and experiments are needed on this aspect. A possible relationship between the level of seed intake and the number of whole seeds in the faeces may make a technique available for measuring grazing intake of pods.

The percentage of whole seeds passed into the faeces is related to seed size. Franklin and Powning (1942) recovered 57 per cent. of uncrushed *Trifolium glomeratum* seeds (weight of 1000 seeds = 0.4 g) which were fed with lucerne chaff. In the present trial 3 per cent. of seeds (weight of 1000 seeds = 3.73 g) was the maximum percentage recovered. Total dry matter intake and the proportion of seed in the intake will also affect the percentage of whole seeds excreted.

The chemical composition of the pods of the commercial strain of *M. tribuloides* used in this trial was very similar to that of strains of barrel medic reported by Franklin and Powning (1942); the pod size of this species varies over a wide range.

The protein intakes of the sheep were high, up to 220 g per day, and greater than the protein intakes of caged sheep fed *ad libitum* amounts of irrigated pasture (90-120 g per day) (Pearce and Vercoe, unpublished data). In the absence of a readily available source of energy, however, it is unlikely that the protein of the pods is utilised very efficiently. Grazing

sheep may or may not, depending on conditions, consume a more balanced ration.

Factors influencing dissemination include the hard seed percentage, the mechanical transport of pods by stock—pods of *M. tribuloides* are not picked up in the wool as readily as the pods of some other leguminous pasture plants—and adverse climatic conditions at the time when the pods are eaten and the seeds defaecated.

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Susceptibility of *Lucilia Cuprina* Wied. to some Organic Phosphorus compounds

Since the development of resistance in *Lucilia cuprina* to Class II insecticides (Hoskins and Gordon 1956; Shanahan 1958), Diazinon has been extensively used as an alternative insecticide for the prevention of blowfly strike in sheep.

Tests have been conducted on a laboratory susceptible strain, with Diazinon and the other insecticides shown in Table 1, to determine the LD₅₀ and variance of female *L. cuprina*. Each insecticide, dissolved in its chosen solvent (see Table 1), was topically applied to the thorax of three to seven days

old insects, whilst immobilized with carbon dioxide. After treatment the flies were held in glass containers at 77°F., and were provided with sugar and water. Mortality records were taken 24 hours after treatment.

TABLE 1

Dosage-mortality tests with organic phosphorus compounds on female L. cuprina.

Insecticide	Solvent	LD ₅₀ (Micro-grams per insect)	Slope of Dosage-mortality Line
Diazinon	Risella oil	0.042	11.55
Trolene	Kerosene	0.031	8.55
Parathion	Kerosene	0.037	9.13
Malathion	Kerosene	0.406	9.81
Rogor	Xylol	0.027	8.26

The LD₅₀ and slope of the dosage-mortality line for each insecticide were calculated by the probit analysis method (Finney 1952), from data obtained from a 6 point log. dosage scale. This data appears in Table 1. Approximately 100 flies were treated at each point.

Acknowledgment

This work is part of a research programme on sheep blowflies being undertaken by the N.S.W. Department of Agriculture with funds provided by the Wool Research Trust Account. The author has been made available by Geigy (Australasia) Pty. Limited, to conduct a study on O.P. compounds.

Thanks are due to Mr. G. J. Shanahan of the Department of Agriculture for help and advice during the investigations and to Mr. F. McCleary for the statistical treatment of the results.

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Book Review

Fungal Diseases of Animals

By G. C. Ainsworth and P. K. C. Austwick

Commonwealth Bureau of Animal Health, (pp. 148. Over 650 references.) Obtainable from the C.A.B. Liaison Officer at 314 Albert Street, East Melbourne, C.2., Victoria. Price 25s.

This is a concise textbook written by two mycologists who have specialized for some years in the fungal diseases of animals.

Each of the 17 chapters deals with a specific disease or group of diseases, for example, bovine mycotic abortion; histoplasmosis; mycotic mastitis; mould toxicoses and poisonous fungi; ergotism, ring-worm; mucormycosis; coccidioidomycosis.

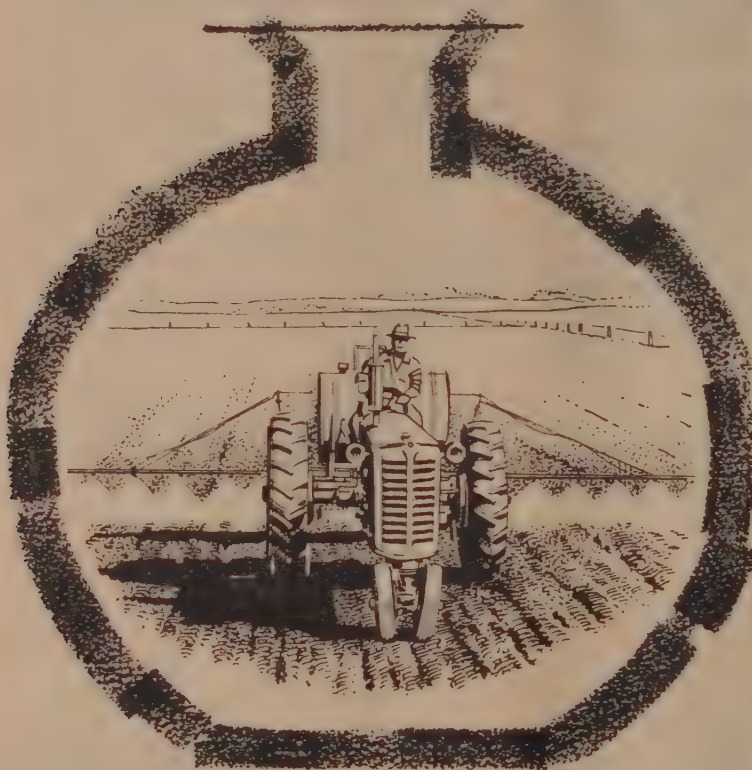
It is the first text in English on this rapidly growing subject, and should be of the greatest value to all veterinarians whether they be practitioners, teachers, students or research workers.

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Theses on which higher Degrees were Awarded in the Faculties of Agriculture of Australian Universities — 1958

University of Adelaide

See December 1958 Journal.

University of Melbourne

M.Ag.Sc.	K. R. Garland	The present and potential productiveness from pastures in the irrigation districts of North Western Victoria.
M.Ag.Sc.	B. Cockroft	Physical properties of some Victorian soils.
M.Ag.Sc.	I. D. Wardrop	Body composition studies in the sheep.

University of Queensland

D.Agr.Sc.	A. E. Martin	Physico-chemical studies on illuvial organic matter from podzol soils.
M.Agr.Sc.	J. G. Morris	Studies on the use of bush hay, silage and cereal grains for maintenance of cattle and sheep.
M.Agr.Sc.	R. G. Florence	The silvicultural management of the major eucalypt associations in south eastern Queensland.

University of Sydney

Ph.D.	J. W. McGarity	Some factors affecting the nitrogen economy of a humid subtropical soil and a semi-arid temperate soil.
M.Sc.Agr.	L. R. Humphreys	Studies in the germination, early growth, drought survival and field establishment of buffel grass (<i>Cenchrus ciliaris</i> L.) and of Birdwood grass (<i>C. Setigerus</i> Vahl.) with particular reference to the Yalleroi district of Queensland.
M.Sc.Agr.	W. F. Musgrave	A study of the economic relationships between beef cattle and sheep in two areas of south-eastern Australia.
M.Sc.Agr.	Helen R. Philpotts	The effect of some fertilizers on germination, survival of root nodule bacteria, nodulation and establishment of pasture legumes on two acid soils.

M.Sc.Agr.	R. T. Shand	A study of the economics of pasture improvement on selected farms in New South Wales.
M.Sc.Agr.	Pan Yu Sheng	The effect of various factors on fibre diameter, number of crimps per inch, and the regression of fibre diameter on crimp in five inbred families of Peppin Merino Sheep.
M.Sc.Agr.	P. H. Walker	A study of the cyclic soils, their relation to landscape and their development on the South Coast of New South Wales.
M.Sc.Agr.	P. G. Williams	The application of plasmolytic methods to studies in barley mesophyll.

University of Western Australia

M.Sc. (Agric.)	N. M. Halse	A study of factors influencing the chloride content of tobacco leaf.
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Thesis Summary

Physico-chemical Studies of Illuvial Organic Matter from Podzol Soils

An improved method of dispersing the humus from podzol B horizons was developed. In this procedure, the soil is extracted with a dilute (0.2-1.0 M) solution of acetylacetone and, after centrifuging, the dark-coloured suspension is ether-extracted to remove excess acetylacetone and its complexes with Fe and Al, with which podzol B humus is thought to be combined in the profile. The physico-chemical properties of such suspensions, obtained by similar treatment of podzolic illuvial horizons from a number of Australasian and overseas podzols, were then examined in an attempt to elucidate further both the podzolisation process and the nature of soil organic matter.

The character of the pH-titration curves of this type of humus, both with and without added metal ions, did not suggest that co-ordination complexes were formed with Cu, Fe or Al. Treatment of the humus preparation with cation-exchange resins caused a further loss of Al and resulted in a marked increase

in cation exchange capacity. Titration of these virtually metal-free suspensions again provided no conclusive evidence of the formation of co-ordination complexes. It was concluded that metal-complex formation was not responsible for the stabilization of humus in podzol B horizons, and that Al (or possibly Fe) was attached to the humus molecule by electrostatic bonding. A critical survey of Bloomfield's papers showed that, contrary to his conclusions, there was no good evidence of metal complex formation in the mobilization of Al or Fe either. It was therefore suggested that co-ordination complexes play no significant part in the podzolisation process.

The significance of electrostatic bonding was then examined in further detail using resin-treated humus, with particular reference to the effect of pH and of organic carbon to metal ratio on the degree of mutual flocculation. It was found that maximum precipitation of humus and metal occurred simultaneously at

about the pH of precipitation of the relevant metal hydrous oxide, i.e. pH 2.8-3.0 for Fe III and pH 4.5 for Al. Above these pH values practically no flocculation of humus was found, although good evidence was obtained for the exchange of humus "anions" for OH from the surface of the freshly formed hydroxide. A consideration of the pH changes which took place on mixing isohydric preparations of metal and humus suggested that maximum flocculation was facilitated by the formation of a polymeric species of aluminium hydrous oxide. Ferrous iron was unable to flocculate humus except at very low C/metal ratios, a feature also shown by nickel. This agrees with the Hardy-Schulze rule governing the flocculation of colloids by ions of different valency. It was concluded that, within the normal range of pH of podzols, Al, rather than Fe III, was responsible for flocculating the organic matter. This hypothesis was supported by earlier observations that the amounts of Al extractable from acetylacetone dispersions of podzols greatly exceeded extractable Fe.

Resin-treated humus was shown to need a critical threshold content of added metal before flocculation occurred. Addition of less than this critical amount sensitized the humus so that only small quantities of other metal species were needed to cause precipitation. This effect was found to be independent of metal ion species; thus a given quantity of humus, which had been sensitized by the addition of Al but which was still dispersed, was completely flocculated by adding a trace of nickel, and vice versa. Furthermore, on treating a stable humus-iron suspension at pH 3.2 with Al, complete precipitation of all three constituents occurred. Thus the simultaneous presence of Al, Fe and humus in the B horizon can be

accounted for solely by the flocculating properties of Al ions.

The results of experiments using pure Al and H-kaolinite and bentonite suggested that sorption of podzol humus by clays in acid soils probably occurs as a result of the presence of exchangeable or surface-sorbed Al. Humus preparations were able to deflocculate Al-clay markedly, suggesting that this process may be of significance in clay movement in acid soils. It is also suggested that this type of clay migration may constitute the primary reaction in podzolisation, since it would account for the presence of both Al and humus in a sharply-defined B horizon.

The pH-titration curves of resin-treated podzol humus were closely similar to those of resin-treated NaOH extracts of a latosol and a black earth. The exchange capacity of all three preparations were all in the region of 600 m-equiv. per 100 g organic matter, a value much higher than that normally quoted. Al-"humate" precipitates prepared from the latosol and black earth organic matter could be re-dispersed with acetylacetone. Further, resin-treatment of NaOH extracts greatly reduced their Al content and their respective yields of "fulvic acid" when acidified according to Oden's separation. It is suggested, firstly, that podzol illuvial organic matter may be chemically similar, in its metal-free state, to the humus fraction from other Great Soil Groups, and secondly, that the separation of soil organic matter into "humic" and "fulvic" fractions has little physico-chemical justification since it seems to be controlled by the amount of Al present.

A. E. MARTIN

Awarded the degree D.Sc.Agr. by the University of Queensland, 1959.

Studies on the Use of Bush Hay, Silage and Cereal Grains for the Maintenance of Cattle and Sheep

A series of four experiments with maiden heifers and two with wether sheep, was designed to study the suitability of native grass hay (bush hay), sorghum silage and grain sorghum as basal fodders for a drought feeding ration.

In two experiments groups of heifers fed long chaffed bush hay *ad lib* alone, or with a salt-bone flour lick, survived the experimental period (21 and 26 weeks) with a slight loss (less than 10 per cent.) of their initial body weight. The salt-bone flour lick although readily eaten was of no apparent benefit. The addition of nitrogen-containing supplements: lucerne chaff (1.3 and 3.0 lb per head per day), meat meal (0.41 lb per head per day) and crushed sorghum + urea (1 lb and 2 oz respectively per head per day) increased total dry matter consumption and permitted body weight increase. In one experiment the ovarian activity of the group of heifers fed the sorghum and urea supplement was increased over the other groups.

A basal diet of sorghum silage *ad lib* permitted the survival of a group of heifers for 28 weeks with an 18 per cent. loss of initial body weight. A supplement of 1.5 oz of urea per head per day fed to a group of heifers with the same silage intake as the previous group halved the body weight loss. When 1.5 and 2.5 oz of urea per head per day were fed to

groups with *ad lib* silage intake the dry matter consumption was 164 per cent. and 182 per cent. of the unsupplemented group; and the body weight after 28 weeks was 118 per cent. and 130 per cent. of the initial body weight. Urea supplemented animals had a higher plasma protein concentration; did not develop the subcutaneous oedema as occurred in heifers fed sorghum silage alone; and showed a greater tendency to shed their winter coats.

In two separate experiments groups of sheep, fed similar silage and bush hay with comparable supplements as the cattle, exhibited a greater percentage loss of initial body weight and did not show a marked response to urea supplementation.

A group of heifers individually fed 3 lb crushed grain sorghum including 1 per cent. limestone as the total daily ration survived an experimental period of 27 weeks with no apparent deleterious effects. These animals, within six weeks of being returned to pasture, had exceeded their pre-experimental weight.

With both sheep and cattle body weight changes were markedly reflected in behaviour patterns; animals on sub-maintenance diets were lethargic, apathetic and dejected.

J. G. MORRIS

Published: *Qd. J. Agric. Sci.* 15, 161-213, 1958.
Awarded the degree M.Sc.Agr. by the University of Queensland, 1959.

Problems Arising During One Hundred Years of Agriculture on the Darling Downs

A series of talks given to a meeting of the Queensland Branch at Toowoomba, October 28, 1959.

Soil Erosion — The Causes rather than the Effect

Mr. W. J. Roche, Soil Conservationist, Queensland Department of Agriculture and Stock.

The Darling Downs was first settled as a pastoral area but subdivision of the large holdings and the development of agriculture rapidly followed. By the turn of the century agriculture on the eastern Downs had become well established and in the nineteen thirties development gained momentum on the plain lands of the Downs with Dalby as the developing economic centre. By 1958, approximately 1,500,000 acres were under cultivation in the Downs Division and cultivation had extended further west to give an estimated 50,000 acres in the Roma Division.

Water erosion quickly showed itself as a hazard on the sloping lands of the eastern Downs, and flooding developed as a problem of the plains. The farmers did little to cope with this insidious menace and by 1958 it was estimated that in the Downs Division approximately 600,000 acres were in need of treatment for erosion.

In 1948 the Soil Conservation Service of the Department of Agriculture and Stock was formed and a free advisory and planning service made available to the Downs farmers. The staff of field officers is now nine with two senior administrative officers in Toowoomba. Two draughtsmen are engaged in the draughting of topographical and property information on to base plans. The field officers add to these designs the mechanical control structure necessary to arrest erosion. These plans, in contrast to earlier work on a single farm basis, are now prepared on a grid and catchment basis

with approximately 5000 acres per grid, using data from army grid maps, parish maps, and aerial photographs.

The preparation of agricultural drainage plans for the division is complicated by the number of participating agents, for example, many plans may require the approval of the farmer, the designing conservation officers of the Agriculture and Stock Department, local Government bodies, Irrigation and Water Supply Department, Main Roads Department, and Railways Department. This situation leads to delay and complication and is badly in need of revision and stream-lining.

Control measures have been applied to approximately 35,000 acres and this area is being increased at the rate of approximately 7,000 acres per annum. The break up of new cultivation is exceeding, by far, the area to which control measures are being applied and there is an actual increase in the area of land suffering erosion. With the present rate of progress at least 30 years will be required for planning alone.

Much of the important local information necessary for the preparation of soil conservation farm plans has yet to be obtained. To this end the Agriculture and Stock Department has two officers engaged in research to provide some of the pertinent information.

Priority has been given to surface¹ drainage schemes, but this in no way indicates the lack of awareness of the major role that good land usage plays in soil conservation. The approach, biased to mechanical control, is necessary, however, to arrest active erosion and allow the subsequent adoption of sound agronomy.

Fertility Decline and its Effect on Wheat Quality and Yield

Mr. J. W. Littler, Agronomist, Queensland Department of Agriculture and Stock.

Wheat was introduced as a crop to the Darling Downs in the 1890's but large scale production did not develop until the late 1920's. From this time on internal combustion engine tractors came into general use.

Though there have been certain changes, wheat agronomy, generally, is much the same as it was 50 years ago. That there is need for further change

is indicated by the decline in fertility that is taking place. In the Brookstead area for example, old cultivations, which formerly produced ten to twelve bags per acre now yield only six to seven bags. Cases of barley supplanting wheat as the economic crop and the appearance of mottling, officially noted as early as 1927, all point to this decline in fertility.

The Department of Agriculture and Stock in recent years has conducted trials with urea on an old cultivation, typical of the Brookstead area where, depending on the seasons, yields of four to seven bags are usual. In this work yield responses of up to 100 per cent. were recorded, protein levels were increased by as much as 5 per cent. and mottling was reduced by half. There was also improvement in quality, as assessed by dough and baking tests. Observation plots on new land all yielded high protein wheat (16 per cent.) while similar plots on old cultivation showed a range of 9 to 16 per cent. protein. These and other trials support the contention that a decline in soil fertility is occurring.

With the growing emphasis on quality, it is highly important that farmers now give consideration to the conservation of organic matter and nitrogen in their soil.

farming system and to arrest the fertility decline and serious erosion which have occurred.

The predominantly summer rainfall of the area necessitates the selection of summer growing perennial species, but selection is also being made for winter annuals capable of exploiting years of good winter rainfall.

The main problem of summer pastures is that of establishment. It is estimated that 0.1 to 0.5 per cent. of the viable seed of Rhodes grass (*Chloris gayana*) yield established plants from sowings on the black earths. This difficulty is the result of rapid drying of the soil surface, and high soil surface temperatures—68°C has been recorded.

Nutritional disorders of crops and pasture legumes occur. One is a simple zinc deficiency which responds to heavy rates of zinc sulphate drilled with the seed. The cause of another is not known and the problem is still under study. It appears as a stunting on a wide variety of crops and is probably not a mineral deficiency.

Pastures and Related Nutritional Problems

Mr. J. K. Leslie, *Agrostologist, Queensland Department of Agriculture and Stock.*

From the first settlement of Leslie in 1840, the Darling Downs was utilized for sheep grazing. In those days the native legumes *Vigna*, *Psoralea*, *Glycine*, and *Rhynchosia* provided valuable herbage. *Panicum decompositum* was widely distributed, but today this species, *Dichanthium sericeum*, and *Eriochloa* spp. are replaced under heavy grazing, by *Panicum queenslandicum*, *Stipa* spp., and *Aristida* spp.

During the late 1800's extensive areas of these pastoral holdings were under lucerne, and from this time cultivation moved towards wheat production. Today, very little native pasture remains, and the majority of the area is cropped to wheat, barley, linseed, millets, sorghum, and other crops. A pasture ley is urgently needed to provide a balanced

Changing Attitudes towards Methods of Pest Control

Mr. A. W. S. May, *Senior Entomologist, Queensland Department of Agriculture and Stock.*

Recent advances in entomological science have enabled the grain grower and pastoralist on the Darling Downs to meet the challenge of pest problems associated with an ever-expanding agriculture. With a few minor exceptions economic controls are available for pests of major field crops.

The chemist has given and is still giving us insecticides which have altered the whole picture of insect pest control. These chemicals, more especially DDT, have rescued the entomology of field crops from the bog of the relatively ineffectual control methods of the thirties. We are at present enjoying a period of successful entomological achievement. As the general pattern of agriculture is ever changing, however, so can the role of pest control be expected to change or require frequent modification.

Thus entomologists must look beyond a mere screening of insecticides if they are to maintain

the status quo. As individual areas expand and the cost of production continues to creep towards the gross return per acre, so must cheaper ways of management be sought. Among other things, this means simpler, quicker, and cheaper methods of application as well as less costly chemicals and more economic dosage rates. These must be implemented without detracting from existing controls, or, at least while maintaining a satisfactory level of economic control.

Cultural methods of insect control, too, have always played an important role in field crop management. Many of these have become standard farmer practice on the Darling Downs. The acceptance of these methods and their application along recognised lines has often obviated the costs of chemical treatments.

The Changing Pattern of Plant Diseases

Mr. T. McKnight, Senior Pathologist, Queensland Department of Agriculture and Stock.

There have been several noteworthy changes in the pathology of cereal and other field crops on the Darling Downs over the last decade, but outstandingly the most important of these changes have been the appearance of new biotypes of stem rust of wheat, and the incidence in epidemic proportions on the heavier textured soils of the eastern Downs of the crown rot disease of wheat caused by *Fusarium graminearum* (Gibberella zeae).

Other noteworthy changes have been the appearance of *Sphaerella linorum* in linseed, *Piricularia grisea* in *Setaria* crops, a large range of bacterial and fungal pathogens in grain and forage sorghums, and the *Phytophthora* red stem canker cowpea disease.

At present the control of crown rot depends on the employment of crop rotations, and the use of certain varieties, notably Lawrence and Festival, which are less prone to the disease. Investigations are being continued into the association of nutrition with incidence of the disease. The effect of frost damage is also being examined.

The Importance of Pasture Legumes to Tasmania

Mr. N. A. M. Kjar, Department of Agriculture, Tasmania, to the Symposium on Pasture Legumes, organised by the Tasmanian Branch and held at Launceston on October 29, 1959.

The total area of Tasmania is less than 17 million acres. Only one half is devoted to rural activities, but over 17 per cent. of this is now under some form of sown improved pastures. This is double the acreage and of much higher average productivity than twenty five years ago.

The rate of increase in improved pasture during the past 14 years has been about 52,000 acres annually, but this is slowing down with the tapering off of both private and State Land Settlement projects. The development of about 10,000 acres a year is expected from the War Service Land Settlement on Flinders Island for another three years, and there is a possibility of some Closer Settlement Schemes on Flinders Island and on the North East Coast.

There remains about five million acres of occupied alienated land still uncleared, some being used as native pastures. Much of this is unsuitable for economic development but there are many large areas where satisfactory improved pastures could be established.

Importance of Legumes as Food and as Soil Improvers

The value of legumes as a part of the ration for animals and for human food has been known since earliest Biblical times. We know now this is due mainly to the protein, mineral and vitamin contents. Lucerne and clover species when actively growing, contain about 3 per cent. protein, while when matured the protein equivalent may be as high as 8 per cent. Wool is 50 per cent. protein. Milk contains over 3 per cent. protein, steak about 19, mutton 16, and white of eggs, peanuts, and lentils of all kinds are very good sources.

The importance of legumes as soil improvers also has been recognised since very early times. However, it was not till 1886 that the mutually beneficial Legume-*Rhizobium* association was reported. Nitrogen accounts for approximately 4/5 of the air, meaning that there is approximately 60,000 tons above each acre from which to draw. Some of our present day permanent pasture legumes such as subterranean and white clovers, when well established, can provide over 200 lb nitrogen per acre each year—

the equivalent of half a ton sulphate of ammonia which would cost about £20 per acre.

Other nitrogen credits are:—

1. From the air, mainly in thunderstorms, small amounts may be gained each year perhaps equal to 4 lb nitrogen per acre in temperate climes with perhaps five times more in tropical areas.
2. Fixation by soil organisms and soil colloids. Bacteria in soils such as *Azotobacter* and *Clostridium* may fix amounts up to 50 lb nitrogen per acre. Some plants such as algae and epiphytes (orchids, figs) can extract some nitrogen direct from the air. Some colloids in the top two inches of some soils may absorb plant nutrients from the air although there is still some uncertainty regarding these processes and the amounts of nitrogen so gained.
3. Fodders from outside sources fed to stock with the dung and urine retained on the land.
4. Fertilisers and or farmyard manures used on the land.

Nitrogenous fertilisers, however, are costly items e.g. 1 cwt sulphate of ammonia providing 21 per cent. inorganic nitrogen, would cost nearly 40s. per cwt on the farm. Nitrate of soda giving 16 per cent. nitrogen would be about 50s. per cwt and 1 cwt blood and bone, costing about 30s. would provide only about 7 per cent. nitrogen and 14 per cent. phosphate. Urea would supply 46 per cent. nitrogen at about 85s. per cwt. Compost and farmyard manure are more bulky items of varying costs and difficulties.

Losses of nitrogen from the soil are:—

1. Food crops harvested and sold off the property e.g. each bushel of wheat means a loss of 1 to 2½ lb nitrogen.
2. Retained by the animal as increased body weight. Each 100 lb increase in a beef animal will take three lb nitrogen while a porker pig or sheep will carry off over two lb. 500 gallons milk will take about 30 lb nitrogen.
3. Fodders fed elsewhere than on the paddock from which they were harvested.
4. Gradual transfer from outlying paddocks, with dung etc. being voided nearer the milking shed or shearing yards.
5. Erosion of top soil as well as considerable losses in the drainage waters.
6. Denitrification and natural soil processes such as a change of nitrates to ammonia and eventual loss as nitrogen gas.

Tasmanian Soils

According to world standards, most Tasmanian soils are low in general fertility, minerals, and other

elements. The most deficient essential soil elements for pasture growth would normally be phosphorus and nitrogen. Calcium and potassium may be in short supply under special circumstances while copper and molybdenum are two other minor elements often required in smaller amounts. Cobalt is not required for plant growth but is essential for animal nutrition.

For present day Tasmanian pastures it is recommended that everything possible be done (including addition of fertilisers such as those just mentioned) to encourage optimum growth of clovers. The clovers will then provide the nitrogen at no further cost, so that the grasses and clovers combined can produce the maximum bulk of high quality pasture. The optimum proportion of clover to grass is generally considered to be between 1:3 and 2:3.

Early History

The first settlement in southern Tasmania in 1803 was quickly developed northwards, with the object of self sufficiency for the state.

As more cleared land and implements became available, growing of cereals (wheat, barley, oats) potatoes and field peas for human food was quickly increased. Generally the matured straw and grain were carted off for threshing and then the straw often burnt. By 1850 the acreage sown to wheat alone was twice the total area now devoted to cereal and pulse crops of all kinds. The acreage of hay was quickly increased for chaff for horses and stock as well as some for export. Later the rich basaltic soils on the North West and North East Coasts were developed because of the profitable Australian market for potatoes and peas.

Soil Fertility Crisis 1927

With 80 per cent. of the arable land then being continuously cropped without any significant restorative treatment, soil fertility was rapidly being exhausted and on many of the farm areas it was not possible to gain a reasonable yield. Weeds were encroaching on arable areas.

In 1927 special reports by several agricultural authorities and by the Development and Migration Commission stressed the very serious situation which had then developed due to the previous land utilisation policies. Sheep numbers had declined by 10 per cent. between 1901 and 1925, cropping for the ten years ended 1924 showed there had been a drop in yield per acre in wheat, barley, oats, peas, potatoes (25 per cent.) and hay in comparison with the previous ten year period ending 1914.

Change in Agricultural Policy 1927 Onwards

The Development and Migration Commission report

stressed the need for soil restorative practices together with a change in agricultural policy to more stock farming. This change in farm policy, assisted materially by improved prices after the depression years in the early mid 1930's, has been expanded over the past 32 years with much success. The basis of the success since obtained has been improved pasture management techniques involving the use of the newer pasture legumes.

In the nineteen thirties, there was considerable concern regarding the failure of pasture clovers and grasses to produce on the ironstone soils in the north, and on some basaltic soils in the north west and north east.

Experiments from 1937 onwards indicated that lime could rectify the problem by improving clover growth. Then in 1941 the value of molybdenum to clover growth and nodulation was discovered at the Waite Research Institute in work on both South Australian soils and Cressy shaley clay loam soils. From 1943, when molybdenum was added to the first 25 tons of molybdenum superphosphate manufactured in Tasmania, improvement in pasture productivity was much more rapid on these and many similar problem soils. The use of molybdenum for improved clover growth has since been extended to many other parts of the State, with about 10 per cent. of the superphosphate now used having molybdenum added.

During the later years of the World War II, there was an urgent need to produce food of all kinds as well as flax fibres. The demand on the partly restored fertility, although heavy, was not sustained too long but the decline in soil fertility became obvious. Then after the war there was a swing

almost entirely over to pasture stock farming. This process has perhaps gone too far and future prices may result in the adoption of a middle course—balanced between restorative and soil depleting practices.

With special new clover seeding inoculation and fertilising techniques, in the last ten years, there has been very satisfactory pasture establishment on many marginal soils under War Service Land Settlement and privately financed projects. This applies not only to King and Flinders Islands, where carrying capacity has been increased from nothing to up to 3 and 4 fat-lamb ewes per acre, but also to many other soils all over Tasmania which were previously considered unsuitable for pastures.

Economic Importance to Tasmania

Present day revenue from rural production (£28 million in 1957/58) is approximately 30 per cent. of the total net from all industries (primary and secondary). Of this 30 per cent. over half (£15 million) or one sixth of all primary and secondary revenue is obtained directly from pastoral pursuits. Some of the revenue from cash cropping which has realised in the vicinity of £3 million in recent years, would be dependent on the soil fertility maintained by the soil resting period under pasture.

While many factors, such as rabbit control and improvement in overseas markets have entered into the relative importance and financial success of the pastoral industry, the use of the pasture legume as a means of supplying nitrogen, must be considered one of the corner foundation stones of improved grassland stock farming husbandry methods now being generally adopted throughout Tasmania.



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Cunningham Laboratory Opened

The C.S.I.R.O. Cunningham Laboratory at St. Lucia Brisbane was officially opened by the Rt. Hon. R. G. Menzies, Prime Minister of Australia, on Monday November 30, 1959. Other speakers at the ceremony were Dr. F. W. G. White, the Chairman of C.S.I.R.O. and the Hon. O. O. Madsen, Queensland Minister for Agriculture and Stock. Among the three hundred guests were members of Federal and State Parliaments, representatives of scientific bodies, and of the grazing and farming communities, and many others who have given encouragement and support to C.S.I.R.O. work in Queensland.

The laboratory which is the first large C.S.I.R.O. building constructed in Queensland, is the Headquarters of the Division of Tropical pastures and also houses the Queensland Regional Soils Group, and representatives of the Divisions of Plant Industry, Mathematical Statistics, and Soils. It is situated next to the University of Queensland, on a three and a half acre site made available by the Queensland Government.

Pasture and soil research work based on the Laboratory is carried out in several important pastoral districts of sub-tropical Queensland by a team of twenty five research officers. They are seeking information which will assist in development of the great pastoral potential of tropical and sub-tropical Queensland. This is the first time that an Australian Prime Minister has opened a C.S.I.R.O. laboratory, and indicates the importance attached by the Commonwealth Government to developing the potential of northern Australia.

Grant to Queensland Agricultural Faculty

The Bank of New South Wales has presented another £250 to the Agricultural Faculty to be devoted to the wool research programme in Western Queensland. Investigations concerned relate to crop growing and fodder conservation.

The appointment of two new members to the Executive of C.S.I.R.O. has been announced. This follows the recent passage of an amendment to the Science and Industry Research Act, enlarging the C.S.I.R.O. Executive.

The two new full time members of the Executive will be Mr. C. S. Christian, Chief of the C.S.I.R.O. Division of Land Research and Regional Survey, and Professor L. G. H. Huxley, Elder Professor of Physics in the University of Adelaide.

Mr. Christian, has been associated with C.S.I.R.O. ever since his graduation from Gatton College and the University of Queensland. He first went overseas in 1931 to study genetics at the University of Minnesota, U.S.A., and in 1933 he held an appointment under Sir Ronald Fisher at the famous Rothamsted Experiment Station in England. On his return to Australia, he undertook wheat and plant breeding research with C.S.I.R.O. in Canberra and Queensland.

In 1946, following a request from the North Australian Development Committee, Mr. Christian organized and directed a team of scientists known as the North Australia Regional Survey. The team has since grown into the C.S.I.R.O. Division of Land Research and Regional Survey, with a staff of over 80. Under Mr. Christian's leadership, the group has carried out regional surveys of large areas of Australia and New Guinea, and agricultural research in selected areas of northern Australia.

Two changes in the top administration of C.S.I.R.O. have also been announced. Mr. Guy B. Gresford has been designated Secretary and Mr. Walter Ives, Executive Officer.

Mr. Ives, graduated in economics at the University of Sydney. He joined C.S.I.R.O. in 1946 as technical secretary of the Division of Plant Industry. He became Assistant Secretary of C.S.I.R.O. in 1950 and Research Secretary (Biological Sciences) in 1952. From 1954-56 he was chief Scientific Liaison Officer at the Australian Scientific Liaison Office in London.

Grassland Society of Victoria

The first committee of the Grassland Society of Victoria was elected at the general meeting of the Society held on 4th December 1959.

Mr. R. D. Croll was elected President and Mr. M. Piggott Vice President. Other positions are as follows. Hon. Secretary, Mr. R. R. Hedding; Hon. Treasurer, Miss G. R. Easton; Hon. Editor, Mr. G. W. Hexter.

Committee Members, Prof. H. C. Forster, Messrs. N. Killeen, W. B. C. Mackie, R. Presse, K. Schoeffell, Dr. D. E. Tribe, Messrs. W. Tromp, R. L. Twentyman and H. Williams.

The Society is planning to hold one field occasion and one or more lectures each year and to produce periodic publications on grassland matters. The committee has already given considerable thought to the most desirable course of action and plans for 1960 are well under way.

The society will provide a meeting place for the discussion of problems and will seek to assist in the dissemination of factual material. It welcomes to membership all persons who are interested in grassland husbandry.

C.S.I.R.O. Splits Animal Division

Mr. D. A. Gill, Chief of the C.S.I.R.O. Division of Animal Health and Production, retired recently after a lifetime of service to the animal industry. A graduate of the Royal College of Veterinary Surgeons, London, he joined C.S.I.R.O. in 1934, succeeding the late Sir Ian Clunies Ross as Officer-in-Charge of the McMaster Animal Health Laboratory in the grounds of the University of Sydney. He took a leading part in the practical development of methods for the control of blow-fly strike in sheep. He has been influential in improving facilities for research for the sheep industry and was closely associated with the establishment of C.S.I.R.O. laboratories at Prospect and Armidale, New South Wales, and Yeerongpilly, Queensland.

For some years Mr. Gill lectured in veterinary bacteriology at the University of Sydney. During the war, he was seconded for a time as Pastoral Adviser to the Department of War Organization of Industry.

Instead of appointing a successor to Mr. Gill, the Executive of C.S.I.R.O. has decided to split the large division into three divisions:—the Division of Animal Genetics, the Division of Animal Health, and the Division of Animal Physiology.

The new Chief of the Division of Animal Genetics

will be Dr. J. M. Rendel, of Sydney. Dr. Rendel came to Australia in 1951 from the Institute of Animal Genetics in Edinburgh. As Assistant Chief of the Division of Animal Health and Production he has taken part in much of the Organization's animal breeding work, and has been particularly interested in cattle. In 1958 he made a report on the cattle industry in Papua and New Guinea for the Department of Territories.

Dr. T. S. Gregory of Melbourne, has been appointed Chief of the Division of Animal Health, with Dr. D. F. Stewart of Sydney as Associate Chief. Dr. Gregory has been on the staff of C.S.I.R.O. since 1926, except for a period of eight years as lecturer in bacteriology at the University of Melbourne, and for war service.

The Division of Animal Physiology will be led by Dr. I. W. McDonald of Sydney. Before being appointed Officer-in-Charge of the C.S.I.R.O. Sheep Biology Laboratory at Prospect in 1955, he had spent several years at the Institute of Animal Physiology in Cambridge, England.

University Enrolments 1958

University	Year of Course				Completed Course in
	1	2	3	4	1958
Adelaide	30	17	15	14	14
Melbourne	62	50	56	41	38
Queensland	61	43	25	19	15
Sydney	51	53	58	45	20 (+ 13 B.Agr.)
Tasmania	10	—	—	—	—
West Australia	31	15	14	12	7
Totals	245	178	168	131	107

Associated Courses:

Wool Technology (Sydney)	12	3	5	2	2
Rural Science (New England) ..	53	23	13	9	—
Agricultural Economics (New England) ..	8	8	—	—	—
Agric. Engineering (Melbourne) ..	—	—	2	2	—

Show Tickets for U.K. Visitors

The Council of the Royal Agricultural Society of England invites overseas visitors engaged in farming, agricultural administration, research and education to apply for guest tickets for the Royal Show to be held this year at Cambridge from July 5 to 8. Guest tickets are intended for agriculturists and their wives resident overseas and give free admission to the Show and Overseas Pavilion.

Applications should state the visitors' names and addresses in England with some indication of their connection with agriculture and, if possible, the days on which they hope to attend. The address of the Royal Agricultural Society is 35 Belgrave Square, London, S.W.1.

Queensland Extension Methods School

The Queensland Department of Agriculture and Stock conducted its Tenth Extension Methods School at Alexandra Headlands in late October. These schools, two of which are held a year, last a fortnight and have been attended by some 300 Departmental Officers. Thirty two advisory and technical officers of the Department's Divisions of Animal Industry, Dairying, Marketing, and Plant Industry attended this tenth course which was designed to bring the officers up to date on modern trends in extension methods. Lectures and discussions covered rural sociology, education psychology, human relations, and various extension methods, and practical work gave officers experience in writing, broadcasting, movie projection, and public speaking.

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February, 1960.

M. A. Telfer,
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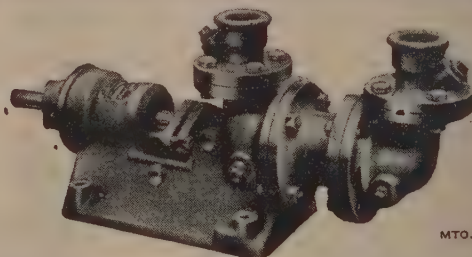
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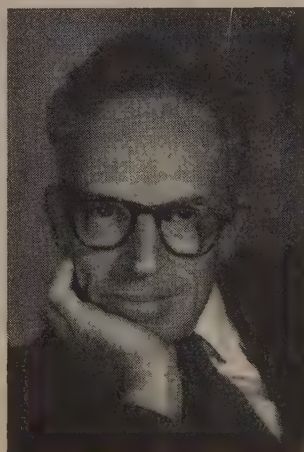
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Fellows of the Australian Institute of Agricultural Science 1959

The class of Fellows of the Australian Institute of Agricultural Science was created to honour members who have made an outstanding contribution to the profession, or to agriculture in general.

Dr. O. H. Frankel, Chief Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization.



Colonel J. K. Murray, formerly Principal, Gatton Agricultural College; Professor of Agriculture, University of Queensland; Administrator, Territory of Papua and New Guinea.



Mr. A. J. Vasey, Divisional Secretary, Division of Animal Health, Commonwealth Scientific and Industrial Research Organization; first Honorary Secretary, Australian Institute of Agricultural Science.



Mr. B. Bartlett has been appointed Officer in Charge of the Poultry Research Section, Department of Agriculture, Werribee.

Personal Notes

New South Wales

Dr. R. L. Reid of the C.S.I.R.O. Sheep Biology Laboratory leaves Australia in March for six months in the United Kingdom, Europe and North America. While abroad he will attend the Easter School on Ruminant Physiology at Nottingham, the International Grasslands Congress at Reading and the International Congress on Nutrition at Washington. *Mr. Warren Musgrave* has left the Rural Research Liaison Section of the Commonwealth Bank to take the post of lecturer in Agricultural Economics at the University of New England.

Mr. T. F. Reardon has recently joined the staff of the C.S.I.R.O. Division of Animal Health and Production at Armidale as a nutritional physiologist. *Mr. Reardon* was formerly employed in post graduate research in reproductive physiology at the University of Sydney.

Mr. T. V. Bourke has recently joined the Northern Sub-Branch of the Institute. He is employed as an entomologist by the Department of Agriculture and is stationed at Graman, some 30 miles north of Inverell. His main work is on pasture grubs, particularly *Othnionius spp.*

Victoria

Mr. P. Ryan, Director of Agriculture returned from an overseas trip in February. He represented the Australian states at an F.A.O. meeting and visited Great Britain.

Mr. W. Stanhope, Poultry Research Officer of the Department of Agriculture is spending a period of 6 months overseas studying latest trends in the poultry industry.

Mr. G. Pearce has resigned from the Department of Agriculture to take up an appointment with the University of Western Australia.

Queensland

Dr. J. Griffiths Davies, Chief of the C.S.I.R.O. Division of Tropical Pastures, is leading the Australian delegation to the 8th International Grassland Congress being held at Reading, England in July, 1960. He will also attend the C.A.B. Conference being held from late August to early October. *Dr. Davies* leaves Australia in late February and pays brief visits to Singapore, Bangkok, and Rome en route to Brazil, Uruguay, and Argentina where he will spend a total of two months studying pasture research and meeting pasture workers. He then travels to Europe and after a six week tour during which he will visit research centres in Belgium, France, Holland, Germany, and Italy, he will attend the Grassland Congress. After the Congress and the C.A.B. Conference, *Dr. Davies* will return to Australia spending a month at research centres in northern U.S.A. and making short visits to Hawaii and the Philippines. He is expected to reach Australia at the end of November.

Queensland delegates to the Congress will be *Mr. S. Marriott*, Assistant Director of Agriculture of the Department of Agriculture and Stock, and *Mr. L. R. Humphreys*, Chief Agrostologist of the same Department. *Mr. Marriott* will examine progress in fertiliser development and various aspects of extension work including liaison between research and extension. He will return through southern U.S.A., Jamaica and Hawaii where he will inspect arid and semi-arid pasture studies, coastal and tropical pastures, special crops, and soil conservation. *Mr. Humphreys* will investigate current pasture work being carried out in the United Kingdom and Holland with particular reference to the physiology of pasture growth and its implications in pasture management. He will also visit Kenya, Rhodesia, and South Africa on his way back to Queensland. Both officers will be away some five months.

Mr. F. Ashraf, a Technical Officer of the Pakistan Industrial Development Corporation, will be in Queensland for some time studying sugar cane agronomy. At present he is at the University studying various soil-testing methods.

Dr. D. O. Norris of the C.S.I.R.O. Plant and Soils Laboratory will commence long service leave on April 19 and he and his wife will spend his seven months leave travelling right around Australia by car. Research stations will have a top priority on his visiting list so members with similar interests in out of the way areas may like to make contact with Dr. Norris on his travels.

Mr. C. T. Gates has been transferred from the Irrigation Research Station, Griffith, N.S.W. to lead the C.S.I.R.O. Division of Tropical Pastures programme of research in plant physiology. Mr. Gates, whose recent work has been in the water relation of plants particularly their reaction to water stress, recently spent some time working with Professor F. Went at the Pasadena Phytotron. His work at the Laboratory will be to study the growth and reproductive responses of tropical pasture plants to important climatic variables such as day length, temperature, and humidity.

Col. J. K. Murray has been in Melbourne for three months as Acting Warden of International House.

South Australia

Mr. H. V. Jenkins, Agronomy Department, Waite Institute, has submitted his resignation from the

University of Adelaide from early in February 1960 to take up an appointment with the University of Sydney.

Mr. J. A. Beare, the Soil Conservator, Department of Agriculture, will go abroad for four months to study recent developments in Soil Science. The tour will include visits to the U.S., U.K., Italy, and Israel with special attention to Soil Conservation and land use and the development of marginal lands.

Mr. W. B. Allden, Agronomy Department, Waite Institute, left Adelaide in January for a year's study leave in England and U.S.A.

Dr. J. P. Quirke, Agricultural Chemistry Department, Waite Institute, has been awarded a Carnegie Travelling Grant to attend the International Soil Society Congress in Madison, Wisconsin, U.S.A. and the National Clay Conference. He will also visit various centres concerned with soil physics and soil chemistry research. He will leave Adelaide in July and will be absent for about four and a half months.

Drs. T. J. Marshall and *E. L. Graecen* will also attend the International Soil Society Congress at Madison, Wisconsin. Dr. Marshall is a vice-president of Commission I (Soil Physics) in this Society. Dr. Graecen hopes to spend some time in Germany and England.

Branch Notes

New South Wales

Branch meetings, in the form of symposia, have proved so successful during the last year, that a further symposium, New Developments in Plant Disease Investigations in N.S.W., was held in November. About 50 people heard the following talks:—

An Eradication Method of Control of Black Spot in Apples, by Mr. K. Hutton.

Brown Rot in Canning Peaches, by Mr. P. F. Kable.
Rodopholus Root Nematode Disease of Bananas in N.S.W., by Mr. C. D. Blake.

Yellow Dwarf Virus Disease of Cereals in N.S.W., by Dr F. C. Butler

The branch drive for membership has met with some success; of the 150 graduates approached about 23 have applied to join. The drive for back subscriptions has been only partly successful, and the committee has taken the realistic attitude of recommending cancellation of membership of defaulters following a final notice.

The branch recently made a submission, prepared by Warren Musgrave, to the Commonwealth Government's Dairy Industry Committee of Enquiry.

In a recent postal ballot, the branch committee of management was reconstituted by the creation of the positions of Hon. Assistant Treasurer to handle subscriptions, Journal Sub-editor, Delegate or Proxy Delegate for each sub-branch and additional members as required.

N.S.W. members in New Guinea have expressed interest in the formation of a branch in that territory.

Victoria

The annual Garden Party to welcome new graduates to the profession was held at the School of Agriculture on December 11. A large number of members and friends enjoyed the buffet meal and refreshments although the "Garden" aspect was rather washed out.

The Branch prize on this occasion was presented to Mr. B. Davidson who completed a distinguished course by obtaining three first class honours and one second class honour in his final year. Mr. Davidson will carry out research at the Biochemistry School, University of Melbourne.

A sub committee was appointed late in 1959 to prepare a submission on behalf of the branch to the Dairy Industry Inquiry. A comprehensive document was drawn up to be presented to the Inquiry during its Melbourne sitting. It was felt that the Institute as an authoritative body with many members closely in touch with all aspects of dairy farming had much useful evidence to present.

Queensland

The November Ordinary General Meeting was held at the Agriculture Building of the University of Queensland at St. Lucia. Prior to the meeting proper, members were conducted over the new Agriculture Buildings by Professor Teakle after which a portrait of Colonel J. K. Murray, the first Professor of Agriculture, was presented on behalf of the Institute to the Faculty by the Branch President, Mr. O. W. Sturgess.

The main business of the meeting was the presentation of papers by the finalists for the A. F. Bell Memorial Medal, a Medal which is awarded annually by the Branch for the best research project carried out by an agriculture student in his third or fourth year of the course at Queensland University. The projects are written up as short papers and three finalists are selected and invited to present their papers to the November meeting.

The finalists for 1959 and the titles of their papers were:—

D. H. MacKenzie—Buffel grass—A review and some aspects of establishment.

C. P. McPhee—Effect of gamma radiation on three *Paspalum* species and an investigation of the mode of reproduction of *Paspalum urvillei* (Steud.)

K. P. Richardson—A comparison of the effect on a pasture of two nitrogen fertilisers applied at different rates and times.

Dr. B. R. Champ on behalf of the selection Committee announced the award of the Medal to Mr. C. P. McPhee and congratulated all three speakers on the excellent presentation of their papers.

South Australia

At a meeting held on October 16, Dr. A. A. Dawson spoke on An Economist looks at Agricultural Science, Farm Management, and Marketing. He is the Agricultural Economist in the Department of Agriculture, South Australia. This meeting was made open to the public.

On November 24, 1959, a seminar entitled The Chemist and Nature was conducted by the South Australian Branch of the Institute at Roseworthy College.

The aim of the Branch was to act as host and pass on scientific information during the day to representatives of agricultural firms in South Australia who had expressed interest in the activities of the Institute.

Due to lack of a large enough suitable meeting place, invitations were kept to a minimum. There was almost a complete acceptance of invitations and an average of one hundred and five attended each session. These were almost all guests as the only Institute members who attended were either giving an address or assisting with the arrangements.

The programme was divided into five sessions entitled Insect Control, Nitrogen as a Fertilizer, Fungus Disease, Plant Growth Regulation and an evening session based on an address Synthetic Fibres in Relation to the Wool Industry by Mr. Lewis Lewis, Officer in Charge, Industrial Liaison Section, C.S.I.R.O.

All speakers were very well received, arrangements went smoothly and without exception comments received were most complimentary.

The Branch should consider that it has made itself known to South Australian agricultural firms with a worthwhile contribution.

Obituary

R. E. P. DWYER

Mr. R. E. P. Dwyer, Director of Agriculture, Territory of Papua and New Guinea, died in the Prince of Wales Hospital, Sydney, on Saturday morning, October 3, 1959. He was 57 years of age.

The late Mr. Dwyer was one of the best known and most liked people in the Territory and his passing will be a loss to his host of friends and to the Administration.

Mr. Dwyer began his agricultural career as an experimentalist in the New South Wales Department of Agriculture after taking Diplomas in Agriculture and Dairy Science from Hawkesbury Agricultural College. As a Cadet of the N.S.W. Department he attended Sydney University from 1923 to 1926, obtaining his Bachelor of Science in Agriculture in 1927. He then took up work as a Plant Breeder with the N.S.W. Department and made valuable contributions in improving lucerne and oats. In 1934 he was appointed Economic Botanist in the Department of Agriculture of the Mandated Territory of New Guinea, but before taking up active duties in the Territory he spent eight months in Java and Malaya studying tropical agriculture.

During his early years in the New Guinea service Mr. Dwyer travelled widely and carried out a number of comprehensive surveys of the main plantation industries in the Territory. He published a series of technical articles on the major crops of New Guinea. His work on coconuts was outstanding and his publications on this crop are still well-known throughout the tropical world. In 1937 he made a survey of the rubber industry in Papua on behalf of the Papuan Administration.

During his years in the Mandated Territory Mr. Dwyer took an active part in all phases of community life and was well known among the sporting fraternity in Rabaul.

At the outbreak of war he joined the New Guinea Volunteer Rifles and was with the unit when the Japanese landed in Rabaul. He escaped from Rabaul and walked across to the North Coast of New Britain where he contacted Mr. McCarthy's party and was evacuated in the "Lakatoi" with the survivors of the Rabaul garrison. On his return to Australia he was released from the Army to carry out investigations of potential rubber producing plants, and he worked in the Charters Towers district. He then

became a member of the Australian-New Guinea Production Control Board, an A.N.G.A.U. organisation which was responsible for controlling agricultural production in Papua and in New Guinea during the war years. Later he was also advisor to the Commonwealth Government on Papua and New Guinea war damage claims.

In 1946 Mr. Dwyer took up an appointment with the provisional Administration of Papua and New Guinea as Economic Botanist and was later promoted to Chief of Division of Agricultural Extension and became Director of the Department of Agriculture, Stock and Fisheries in 1952. He was appointed as a member of the Executive Council in 1950 and as a member of the Legislative Council in 1952.

In the early post-war years, working in collaboration with the late Mr. J. B. McAdam and others, a resources survey was produced which was a useful background paper for the planning of post-war Administration activities. Mr. Dwyer was a member of a number of Boards including the Copra Marketing Board, Copra Industry Stabilization Board and the Land Board. During his career in the Territory Mr. Dwyer made a major contribution not only to the development of our primary industries, but also to general Administration policies.

Mr. Dwyer was a very active Club member and his genial good fellowship will be missed in many of the local clubs. He will long be remembered for his kindness and courtesy to all who had dealings with him.

Mr. Dwyer is survived by his widow and two daughters.

F. C. HENDERSON

IRENE STEWART

Members heard with deep regret of the death in a motor accident of Miss Irene Stewart, Livestock Research Officer at the Animal Research Centre, Werribee.

Miss Stewart graduated B.Agr.Sci. from Melbourne University in 1943. She joined the Poultry Section of the Department of Agriculture in 1945 and took charge of the Poultry husbandry research centre at Werribee in 1948.

Following an overseas trip in 1957 she commenced a breeding programme to develop suitable strains of broilers.

Miss Stewart had a wide practical knowledge of poultry matters and her untimely death is a great loss to the industry.

JAMES FREDERICK BARRETT

"Dan" Barrett was killed by lightning on the golf links at Armidale, N.S.W., on February 14.

He was born at Mudgee, N.S.W., in 1918. In 1938 he gained a Diploma in Agriculture with honours at Hawkesbury Agricultural College and graduated in Veterinary Science, also with honours, at the University of Sydney, 1943. While at the University he held the McGarvie Smith Scholarship.

After graduating he joined the C.S.I.R., at the McMaster Laboratory in Sydney and was then attached to the C.S.I.R. Field Station, "Chiswick" at

Armidale, where he carried out research connected with parasitology and sheep husbandry problems in the New England District.

For two years, 1946-48, he worked with the Morrinsville Veterinary Club at Matamata in New Zealand. He rejoined the C.S.I.R.O. Field Station at Armidale in 1948 and for a number of years has been Executive Officer of the Research Committee, administering that Station.

Dan was an active member of the New England branch of the Institute. He was well respected by his fellow officers and will be sadly missed both by them and the rural community of New England.

JOURNAL OF THE BRITISH SOCIETY OF ANIMAL PRODUCTION

Contents of Volume 2, No. 1, March, 1960.

BLAXTER, COWLISHAW & ROOK: Potassium and Hypomagnesaemic Tetany in Calves.

DASSAT & SARTORE: Effect of Inbreeding on Lamb Weights of Sardinian Sheep.

KING & ROBERTS: Carcass Length and Vertebrae Number in the Bacon Pig.

PRESTON, GREENHALGH & MACLEOD: Effect of Hexoestrol on Ram, Wether and Female Lambs.

BURGESS & LAMMING: Effect of Hormones on Fattening Lambs and Hoggets.

BURGESS & LAMMING: Effect of Diethylstilboestrol, Hexoestrol and Testosterone on Fattening Beef Steers.

WATSON: Milk yield and Butterfat Percentage in Twin and Single-born Cattle.

PRESTON, AITKEN, MACLEOD, MACDIARMID & ROSEN: Effects of Hydroxyzine Dihydrochloride on Fattening Cattle.

PRESTON, RATTRAY & WHITE: Feeding Formalin-treated Skim Milk to Calves.

HODGES & O'CONNOR: An Investigation into Self-Feed Silage Practices.

CRICHTON, AITKEN & BOYNE: Effect of Plane of Nutrition on Dairy Cattle.

This journal is a continuation and expansion of the **Proceedings of the British Society of Animal Production** (1951-8) and appears twice a year in March and September. The annual subscription is 30s. (\$5.00 in U.S.A. and CANADA), single parts 17s. 6d. (\$2.75 in U.S.A. and CANADA) net. Orders and subscriptions should be sent to:—

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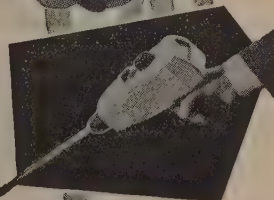
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Salary: Senior Research Officer, £2,395-£2,720, Research Officer, £1,510-£2,265. Female rates are £180 per annum less than the above.

Location: Prospect, Sydney, N.S.W.

This laboratory is a major research centre specializing in the physiology, biochemistry and ecology of sheep. The current laboratory research programme includes investigations of endocrinology, microbiology, climate physiology, energy and nitrogen metabolism, reproductive physiology, dermatology, and nutrition. An Isotope Chemistry Group is collaborating with several Sections as well as pursuing its own studies. Facilities for research are extensive and include modern laboratory accommodation, large animal houses, workshops, and small experimental pastures.

Duties: Applications and enquiries are invited from suitably qualified persons who will consider working in the following fields:—

1. The physiological basis of individual variations in wool production.
2. Ecological aspects of wool production.
3. Pasture evaluation in terms of animal production.
4. Biochemistry of wool follicle.
5. Hormonal control of protein metabolism.
6. Tissue metabolism in the ruminant.

Qualifications: Applications will be considered from Honours graduates in Science, Agricultural Science, or Veterinary Science, with at least two years post-graduate research experience which has given them good research training in physiology, biochemistry, animal husbandry, or ecology. Applications and enquiries from research workers in fields not strictly associated with those proposed above are warmly invited.

Applications quoting reference number 205/183 should reach:—

The Chief,
Division of Animal Physiology,
C.S.I.R.O.,
P.O. Box 144,
Parramatta, N.S.W.,

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